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ABSTRACT

The purpose of this safety manual is to provide a resource to help manage and minimize potential risks in science classrooms where students spend up to 60% of instructional time engaged in hands-on activities. This manual contains information on standards, legal aspects, and responsibilities for science safety; general laboratory safety for students; laboratory facility design; lab safety equipment and accident response; first aid; laboratory equipment safety; chemicals; plants and fungi; animals; and animal safety considerations for biological laboratories. The laboratory safety and accident response section addresses issues such as eye protection, eyewash stations, safety showers, earthquake preparedness, and general housekeeping. (DDR)

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SCIENCE SAFETY MANUAL

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Fire Department _____

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Hospital Emergency Room _____

Missouri State Poison Control Center 1-800-392-9111
Cardinal Glennon Regional Poison Control Center ... 1-800-366-8888
St. Louis Area .. (314) 772-5200

Local Conservation Agent _____

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Missouri Secondary

Science Safety Manual

Prepared by Judith L. Lemons, Ph.D.
through a grant from the Department of Elementary and
Secondary Education under authority of House Bill #2.

1997
Missouri Department of Elementary and Secondary Education
Robert E. Bartman, Commissioner of Education

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Introduction

Safety is a fundamental concern in all experimental science. In recent years, great strides have taken place to ensure a safe learning environment for all children. The National Science Teachers Association Position Statement for Laboratory Science at the Secondary Level stresses the need for all high school science courses to have a laboratory component and that a minimum of 40% of science instruction time be spent on laboratory-related activities.

The purpose of this Secondary Science Safety Manual is to provide a resource to help manage/minimize potential risks of an inquiry-based science curriculum. Teachers should become thoroughly familiar with the contents of this publication and keep it readily accessible throughout the school year.

This document has been prepared under careful supervision and with the latest in available information and resources. It has been reviewed by secondary science teachers, science supervisors, and university educators. While great care has been taken to ensure the accuracy of its contents, this publication cannot describe every safety issue in every possible educational setting. Teachers and school officials are encouraged to use this manual as a general guide to safety and as a resource in obtaining more detailed safety information and training.

C.J. Varnon, Science Consultant, Curriculum Services
Missouri Department of Elementary and Secondary Education

STANDARDS, LEGAL ASPECTS, AND RESPONSIBILITIES FOR SCIENCE SAFETY

The **Missouri Show-Me Standard 4.7** states, "Identify and apply practices that preserve and enhance the safety and health of self and others." This statement emphasizes the importance of minimizing risks in the science laboratory for the teacher, as well as the student. There are several other agencies or organizations which have recommendations for science safety in the schools. The following is a summary of safety guidelines that pertain to Missouri school science programs.

Missouri North Central Association

The annual report prepared by a school for North Central should address the following Association Standards (only the parts relevant to science laboratories are included):

- **9.16** Proper precautions shall be taken to prevent injuries in laboratories.
- **9.20** Regular inspections for fire safety by fire or police inspectors shall be conducted. An adequate number of regularly inspected fire extinguishers shall be designated and shall be properly maintained.
- **9.22** A review and inspection of all safety and emergency procedures and equipment shall be conducted annually by a member of the school's administration.
- **9.26** Inspections of the school to identify safety hazards shall be made and recorded regularly and identified deficiencies shall be dealt with promptly.

The Missouri School Improvement Program (MSIP)

Standard 14.4 states, "Science laboratories **have/do not have** adequate storage of chemicals, eyewash stations, chemical/fire blankets and hooded ventilation." MSIP personnel look for locked chemical storage, eyewash stations (no eyewash bottles) and hooded ventilation in any laboratory where chemicals are used, and fire blankets in any laboratory where heat sources are used. They also check for adequate numbers of approved (Z87) safety glasses and a master shut-off for gas.

Standard 14.2 states, "Facilities and grounds are periodically inspected by appropriate personnel for potential safety hazards; corrections are made promptly to ensure that local and/or state public safety requirements are met." These inspections and corrections must be documented. This Standard also states, "Staff members and students are trained in the safe and proper use of all safety and emergency devices where applicable" and "A reporting system for accidents is maintained."

Arthur J. Gallagher & Company

Arthur J. Gallagher is the servicing broker for a protected self-insurance pool, the Missouri United School Insurance Council, which insures about 90% of the public schools in Missouri. They use the checklist at the end of this section in training sessions for teachers, and inspect schools for compliance with the checklist safety factors. Recommendations are sent to schools following the company visits, and schools are expected to return written progress reports of recommendation compliance. Arthur J. Gallagher & Company also recommends that teachers use student safety contracts (see sample on p. 13)

National Science Education Standards (1996)

NSE Standard D specifically addresses the need for science teachers to ensure a safe working environment for the students. **Teaching Standard D** states, "Safety is a fundamental concern in *all* experimental science. Teachers of science must know and apply the necessary safety regulations in the storage, use, and care of the materials used by students. They adhere to safety rules and guidelines that are established by national organizations such as the American Chemical Society and the Occupational Safety and Health Administration, as well as

by local and state regulatory agencies. They work with the school and district to ensure implementation and use of safety guidelines for which they are responsible, such as the presence of safety equipment and an appropriate class size. Teachers also teach students how to engage safely in investigations inside and outside the classroom."

In order for safe science experiences to take place, **Program Standard D** addresses the need for adequate space "for students to work together in groups, to engage safely in investigation with materials, and to display both work in progress and finished work. There must also be space for the safe and convenient storage of the materials needed for science." **System Standard D** deals with the need for teachers to have the time and resources necessary to implement safe and effective science education.

Administrative Support for Safety

The teacher's job of providing a safe laboratory experience is obviously much easier when supported by the school administration. As indicated in a study of Missouri schools (Lemons, 1993 Doctoral Dissertation, *Status of Safety in the Missouri High School Chemistry Laboratory)*, science laboratories are significantly more likely to have adequate safety equipment, laboratory enrollment within guidelines, and safe storage of chemicals with an adequate disposal program when administrators are actively involved in the process. Administrative support has more effect on compliance with safety guidelines than school size or teacher safety training.

An administrator may demonstrate leadership and support for laboratory safety by:

- actively supporting funding of safety equipment and other safety requirements
- requiring annual laboratory safety inspections
- participating in laboratory safety inspections
- participating in a school science laboratory safety committee
- evaluating all laboratory accident reports
- including a safety evaluation as part of the teacher performance rating process
- providing safety workshop opportunities for the teachers
- assisting in the formulation of a school science safety policy or Chemical Hygiene Plan
- assisting in planning the proper disposal of unwanted chemicals
- verbally encouraging safe practices in the laboratory

Legal Aspects of Science Safety

Teachers, district science specialists, and administrators are legally responsible for the safety of the student in the science classroom. It is more than just a good idea to practice risk reduction. In recent years, there has been increasing concern regarding liability in relation to any student injury. A teacher, science specialist, or administrator may be shown liable if an accident can be shown to be the result of some action, or lack of some action. The teacher is considered to be the *expert* in the classroom laboratory, and so has the ultimate responsibility to see that experiments are carried out in a safe manner.

The legal principles involved are part of *tort law*. A tort is a wrongful act causing damages which may give rise to a civil suit. If a person is injured, these are often called personal injury cases.

Torts may be based on allegations of *negligence*. Negligence is defined in Black's Law Dictionary as "the omission to do something which a reasonable man, guided by those ordinary considerations which ordinarily regulate human affairs, would do, or the doing of something which a reasonable and prudent man would not do." The dictionary states that "one is not 'negligent' unless he fails to exercise that degree of reasonable care that would be exercised by a person of ordinary prudence under all the existing circumstances in view of probable danger of injury."

Carelessness is another liable action. The law basically requires the teacher to be reasonable and to use common sense. Teachers are required to exercise the skill and training which would ordinarily be expected from someone in their profession. This requires an understanding of the substances and materials that teachers and students will be using.

whether they are a chemical or a combination of chemicals, animals, plants, or laboratory equipment. Ignorance is *no defense*.

This manual cannot list all possible problems, but may serve as a baseline for further study. Teachers must gather the information needed to reasonably assess the risk versus the benefit of any activity. As professionals, teachers are obligated to provide a healthy and safe environment in the classroom. No science laboratory situation will ever be totally risk-free, but risks can be held to a minimum by appropriate planning, instruction, and supervision.

School administrators should be actively involved in science laboratory/classroom safety, and must be responsive to correcting areas of safety concern. An administrator may be found negligent if a problem (such as leaking gas valves, lack of appropriate chemical storage, faulty wiring, etc.) has been presented by a teacher but is not addressed in a reasonable time. Administrators should ensure that teachers have appropriate safety training and time to implement safe practices.

Teachers should evaluate the benefits of carrying liability insurance. Several teachers' organizations offer policies.

General Safety Guidelines

In a civil suit, the plaintiff must prove that the defendant had a duty, there was a breach of duty, the breach of duty accounted for the negligence or carelessness, and this was the *proximate cause* of the injuries or damage. Some general safety guidelines for teachers will help to keep students safer, and help to reduce individual and district liabilities due to negligence or carelessness.

1. **Conduct ongoing safety education.** Teach a safety unit at the beginning of each course, with mastery required before a student may conduct any experiments. Provide verbal instructions for any specific safety concerns before each activity and distribute printed safety instructions with the lab experiment handout which may be unique to that experiment. Document these instructions in lesson plans. Post general safety rules on classroom walls or bulletin boards. Some science supply companies have safety education materials. Two non-profit sources of audio-visuals, videos, teacher safety courses, newsletters, etc. are the Laboratory Safety Workshop (see p. 65) and the American Chemical Society Division of Chemical Health and Safety (their Web site has links to safety sites at http://dchas.cehs.siu.edu).

2. **Prepare for accident response.** Provide two exits from the laboratory. Designate certain students to immediately contact the school nurse and/or principal if needed. Practice responses to burns, cuts, spills, and fires, and practice use of the eye wash, safety shower, and fire blanket. Assign each student a "safety partner," someone who can immediately assist the other in any situation.

3. **Practice foreseeability**. Understand the possible risks of an activity and take steps to reduce these hazards. For example, demonstrate how to heat an alcohol before students use this procedure or use lower concentrations and lesser amounts of chemicals when possible. Also take steps to limit personal injury if an accident does occur by requiring safety goggles and other appropriate protection. Have a contingency plan in case something does happen. *Always* try an activity before presenting it to the students. Don't trust that all will take place as described in the text or lab manual. Check equipment and glassware to ensure good condition and cleanliness.

4. **Conduct a safety inventory of the classroom.** The checklist following this section may be used as a guideline and starting point. The National Science Teachers Association recommends a minimum of four square meters of laboratory space per student. They also recommend that because of the safety considerations and individual attention needed by students in laboratories, science class size be limited to 24 students unless a team of teachers is available. See page 7 for further class size recommendations.

5. **Provide safety goggles for students, teachers, and visitors. Goggles are required by Missouri law in any situation which might present a hazard.**

Chapter 170, RSMo, states:

170.005. Eye protection required, when.- *Every student, teacher and visitor is required to wear an industrial quality eye protective device when participating in or observing any of the following courses in schools, colleges, universities or other educational institutions:*

(1) Vocational, technical, industrial arts, chemical, or chemical-physical shops or laboratories involving exposure to the following: Hot molten metals, or other molten materials; milling, sawing, turning, shaping, cutting, grinding or stamping of any solid materials; heat treatment, tempering, or kiln firing of any metal or other materials; gas or electric arc welding, or other forms of welding processes; repair or servicing of any vehicle; caustic or explosive materials;
(2) Chemical, physical, or combined chemical-physical laboratories involving caustic or explosive materials, hot liquids or solids, injurious radiations or other hazards not enumerated.

170.007. Industrial quality eye protection devices defined.- *As used in sections 170.005 to 170.009* ***"industrial quality eye protective devices"*** *means devices meeting the standards of the American National Standard Practice for Occupational and Educational Eye and Face Protection, Z87.1-1968, and subsequent revisions thereof, approved by the American National Standards Institute (ANSI), Inc.*

170.009. Instructions and recommendations for eye protection to be prepared by boards.- *The State Board of Education and the Coordinating Board for Higher Education shall prepare and circulate to each public and private educational institution in this state instructions and recommendations for implementing the eye safety provisions of sections 170.005 to 170.009.*

Contact lenses are not recommended for wear in the laboratory. See page 17 for more complete guidelines for contact lenses and eye protection. The teacher should keep a written record of any student who does wear contact lenses so that appropriate action may be immediately taken in case of an eye injury.

6. **Never leave students unsupervised**. Plan ahead so there is no need to leave the room. In an emergency, the first responsibility of the teacher is to prevent any further injury to students. If a teacher must leave the room, another adult should stay with the remaining students. A court of law will almost always find a teacher negligent should an accident happen while the teacher is unavailable, whatever the reason for the absence. Do not allow a student to work alone, for example on a special project or for a make-up lab. For personal safety, a teacher should also have someone within calling distance whenever working in the laboratory.

7. **Keep all chemicals in locked storage facilities**. Keep all chemicals in proper storage except for those being used in experiments. Do *not* allow student access to storage rooms.

8. **Be trained in first aid and CPR.** Thousands of science-related accidents occur each school year. Almost all are very minor, such as small cuts or burns. Every teacher should take a recognized first aid training program so that immediate care may be given to a person who has been injured in the classroom, especially if no school nurse is available. The Missouri Good Samaritan Law (Section 537.037, RSMo) offers limited protection if the assisting person has been instructed in a recognized training program.

9. **Be aware of students with allergies or other medical conditions which might limit activities**. Contact the school nurse or school office at the beginning of the school year to get student medical information which is pertinent to student participation in science experiments. Try to limit student exposure to allergens if a student has allergies, and be familiar with the necessary first aid treatment. Send a list of chemicals, plants, organisms, and equipment which will be used in the class to the physician of any pregnant student so the doctor may make the decisions regarding the student's

participation in activities. Any pregnant teacher should take the same precautions.

10. **File written accident reports with the administration as soon as reasonably possible.** Keep a copy signed by the principal for your records. See page 25 for more information regarding accident report information.

11. **Encourage adult supervision of any home activity.** Carefully evaluate student requests for materials or chemicals to use at home. The teacher is legally responsible for results from any activity using supplies the teacher has given to the student. The teacher should provide written and verbal safety instructions if materials are given to a student for a home project (including science fair projects).

12. **Arrangements should be made to ensure the safety of handicapped students.** Do not isolate the disabled student from other classmates. Laboratory benches, science equipment and supplies, and safety equipment should be accessible to all students.

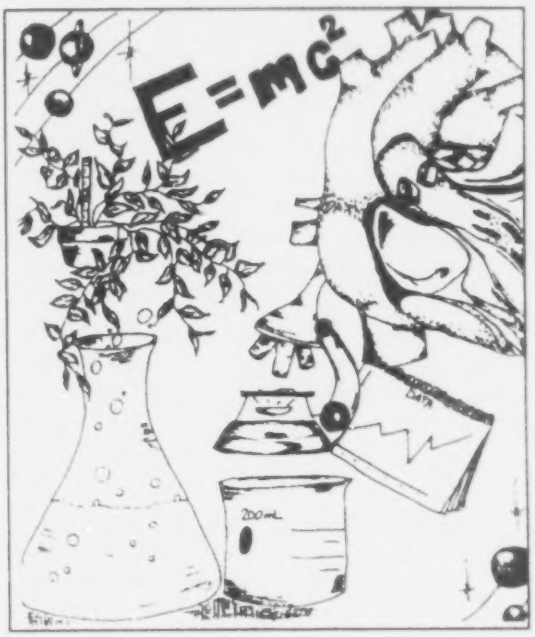
The National Science Education Leadership Association recommends that there be no more than 22 students in a laboratory class if at least two of these students are classified as having special needs. If three students have special needs, the total number of students should not exceed 20. There should never be more than three special needs students in any one lab section unless the science teacher is assisted by trained professional or paraprofessional help.

Science Activities for the Visually Impaired (SAVI) and Science Enrichment for Learners with Physical Handicaps (SELPH) have developed specialized equipment and activities for impaired, handicapped, and disabled students. SAVI/SELPH is a program funded by the U.S. Office of Education which has been used from first through tenth grade (address on p.66).

The American Association for the Advancement of Science (AAAS) founded the Project on Science, Technology, and Disability in 1975 to improve the entry and advancement of people with disabilities in science, math, and engineering (address on p. 65). Ask for the AAAS publication #91-27S "Barrier FREE in Brief: Laboratories and Classrooms in Science and Engineering" and other information as needed.

The American Chemical Society (address on p 65) publishes a free manual "Teaching Chemistry to Students with Disabilities."

A handicapped student may not be able to respond quickly to an accident such as a spill or broken glass, so using safety goggles and lab aprons is especially important. All emergency safety equipment such as eye wash stations or safety showers should be easily accessible to all students. Visually impaired students should have laboratory orientation prior to the first day of class so they may locate safety equipment and emergency facilities. A lab partner should be ready to assist whenever there is a need.



Chemistry Laboratories and Laboratory Storerooms Check List

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		YES	NO
1.	Is the amount of glassware and chemicals kept to a minimum in work areas?		
	Are safety bottles used for storage of chemicals? (Plastic coated)		
2.	Is the housekeeping satisfactory?		
	Are classrooms and storerooms regularly inventoried, and no longer needed items properly disposed of?		
3.	Is all electrical equipment properly wired?		
	Do any cords have splices, cracked or frayed insulation?		
	Are outlets properly grounded?		
	Are G.F.I (*referred to as GFCI in this manual)* outlets installed near sinks and wet area?		
4.	Is a fire blanket mounted on the wall?		
	Are it non-asbestos?		
	Inspected yearly?		
5.	Is eye protection available and worn when needed?		
	Are both goggles and face shields available?		
6.	Are emergency eyewash stations and emergency showers available and inspected/ tested monthly?		
	Are students instructed in their use and immediate action necessary?		
7.	Are spill kits available?		
8.	Are ladders available in storage room if needed?		
	Is a safety stool available in the storage room if needed?		
9.	Are heavy items stored on lower shelves?		
	Are shelf brackets in good condition?		
	Do shelves have center supports?		
	Do shelves have front edge "lips"?		
10.	Are chemicals kept at a sufficient operating level, i.e. not overstocking?		
	Are they inventoried at least annually, oldest chemicals used first?		

		YES	NO
11.	Are chemicals clearly labeled?		
	Are labels replaced immediately when damaged or missing?		
12.	Are like materials stored together?		
13.	Are flammable liquid storage cabinets clearly labeled as to their contents, and ventilated to the outside?		
14.	Are large containers of acids stored together on bottom shelves in an acid storage cabinet?		
	Are shelves and brackets inspected regularly and repaired as needed?		
15.	Are areas available for working (burning, heating, using hot plate, mixing, etc.) other than in stock rooms? (Stock rooms should be used for storage only.)		
	Are fume hoods available for teacher and student use?		
	Are fume hoods of sufficient size and number for class?		
16.	Are shelves fastened to the wall?		
	Do they have center supports to prevent sagging?		
17.	Are safety edges installed on the front edges of the shelves to prevent bottles from falling off?		
18.	Is the ventilation adequate for work performed?		
	Is an additional ventilation system installed in the classroom and storage room to exhaust fumes?		
	Will fumes reenter the building?		
19.	Is access to the area limited to authorized personnel?		
	Is a special key or lockset used to restrict areas?		
20.	Are the chemicals and supplies in the storeroom inventoried?		
	Does this include both "open" and "unopened" supplies?		
21.	Is the local fire department aware of this area with the types and amounts of chemicals stored?		
22.	Is a telephone or other signaling device readily available in each area in the event of an emergency?		
23.	Are emergency procedures established to obtain fire and/or ambulance assistance?		
24.	Are building custodians and maintenance personnel advised as to potential dangers, and cleanup procedures (i.e. what not to mop up)?		
25.	Is there a master gas shutoff valve for the entire laboratory?		

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		YES	NO
	25 cont. Does the master gas shutoff valve work?		
26.	Is there a master electricity shutoff control for the entire laboratory (except lighting)?		
27.	Is there a master water/demineralizer shutoff control for the laboratory?		
28.	Are fire extinguishers visible, easily accessible?		
	Are they multi-class (i.e. ABC), and are instructors/staff trained in their use?		
29.	Is there a glassware drying rack available?		
	Are procedures established for handling/ disposing of broken glass?		
30.	Are procedures established for the proper/safe, and legal disposal of used or un-wanted chemicals and equipment?		
31.	Are carts used for the transporting of chemicals and equipment through the lab?		
32.	Are vacuum pumps equipped with shields to prevent contact with the drive belt and pulley?		
	Is glassware used with the vacuum pumps shielded or wrapped to prevent shattering?		
33.	Are safety shields available and used between experiments and students?		
34.	During laboratory exercises, are the extra books, coats, supplies kept away from the work areas?		
	Are the work areas cramped and cluttered?		
35.	Are high pressure gas cylinders properly secured at all times?		
	When they are moved, is proper moving equipment used?		
	Are tanks capped when not in use?		
36.	Is mercury used in the classroom?		
	If so, is a mercury siphon available in the event of a spill?		
37.	Are chemical-resistant aprons available and used for students and staff?		
38.	Is glassware in good condition? No chips or cracks?		
39.	Are hot gloves and tongs used for handling hot materials?		
41.	Is a policy/procedure form established, which is reviewed and signed off at the start of each course?		
	Are parents' signatures required (if minors)?		
42.	Are books on hazardous properties of chemicals available for staff/faculty use? (e.g. N. Irving Sax Dangerous Properties of Industrial Chemicals, Merck Index, etc.)		

		YES	NO
	42, cont. Are these books on hazardous properties of chemicals consulted prior to a lab setup or whenever a chemical is used?		
43.	Are scales and other "readily stolen" equipment secured when not in use?		
	Are they engraved or marked with school identification?		
	Are serial numbers recorded and on file for all equipment?		

Additional items which may be added to the above safety checklist include:

		YES	NO
1.	Does the laboratory have two exits?		
2.	Does the chemical storeroom have heat/smoke alarms which can be heard in the classroom/ laboratory and hallway or are part of the whole-school alarm system?		
3.	Does the laboratory have heat/smoke alarms which can be heard in the hallway or are part of the whole-school alarm system?		
4.	Are safety rules posted in the laboratory?		
5.	Does the teacher include safety as a part of each pre-lab discussion?		
6.	Are safety procedures documented in the teacher's lesson plans?		
7.	Is there a first aid kit in the laboratory if a school nurse is not always available?		
8.	If the answer to #7 is yes, is the teacher trained in basic first aid?		
9.	Are chemicals stored below eye level?		

A checklist is not meant to find fault, but to help determine where improvements are needed. Few schools are immediately able to make all necessary corrections, but priorities may be made for planned implementation. Information from this manual could be used to develop similar checklists for biology, physics, or earth science, if needed. Many of the above items will apply to these laboratories.

GENERAL LAB SAFETY FOR STUDENTS

Safety in a science class is a combination of knowledge, preparation, and common sense. Responsibility for safety should be shared with the students. Because of the variety of materials used in the laboratory, additional student behavioral rules will be needed. Any object or chemical may be dangerous under given circumstances; this lesson needs to be learned and applied in all situations.

It is a good idea to post lab rules in the classroom and to give a copy to each student. Many teachers have the students sign a *lab safety contract* (or "Rules Agreement") during the initial safety unit, in which students agree to certain behaviors. See the following page for a sample of a student contract. While this contract does not free the teacher from liability or responsibility for on-going safety education, it does demonstrate prior planning and helps to make students more conscious of personal responsibility for safety. It is important to include safety guidelines with other written instructions when pertinent to a specific activity. These safety instructions also need to be given orally at the beginning of the experiment.

Suggested Guidelines for Student Behavior

1. **Do not eat, drink, smoke, or apply makeup in the lab.** Keep hands away from the face. Wash hands and work area with soap and water when an activity is complete.

2. **Contain long hair and loose clothing.** Do not wear long necklaces and bulky bracelets on lab days or remove them during the lab. Any of these may contribute to fire and spill problems. Wear shoes which provide protection against spills or dropped objects.

3. **Wear safety goggles.** It is the law in Missouri (see p. 6). Prescription glasses are not a substitute. Contact lenses are not recommended for wear in the science laboratory (see p. 17).

4. **Know how to use the safety equipment.** Work with a partner so that one may assist the other in the case of any accident or injury.

5. **Demonstrate safe behaviors.** Stay in the assigned work area. Keep the area as uncluttered as possible; only the lab manual, notebook and pencil or pen, and experimental materials should be on the lab table. Clean up all spills or broken equipment as soon as possible. Notify the teacher of any hazards.

6. **Conduct only those experiments which have been authorized by the teacher.** Untested combinations of chemicals or materials can be very dangerous and do serious damage to students and the classroom.

7. **Do not point heated containers such as test tubes or flasks at anyone, including oneself.**

8. **Dispose of all waste materials safely.** Put all waste glass in one container, paper products in another, and chemicals as directed by the teacher.

9. **Do not taste, smell or touch any chemical without teacher permission.**

10. **Stay out of the material storage areas.**

11. **Do not remove any materials from the classroom without permission from the teacher.**

12. **Do not work alone in the laboratory.**

Sample Safety Contract (or Rules Agreement) for Students

Student Safety Contract

I will:

1. follow all instructions given by the teacher and/or written in the experiment.
2. wear proper protection for eyes, face, hands, and body as needed during laboratory activities.
3. NOT smoke, eat, drink, or apply makeup in the laboratory.
4. perform only experiments which have been authorized by the teacher.
5. know the location and use of all classroom safety equipment and understand emergency procedures.
6. carefully dispose of all waste materials as directed by the teacher.
7. behave in a responsible manner at all times.

I, _____, agree to abide by these safety regulations and any additional safety instructions given by the teacher. I understand that I may lose laboratory privileges if I fail to fulfill this agreement.

_____ _____

Signature Date

Each teacher may individualize the safety contract to have the maximum use and impact in the classroom. The importance of this agreement is reinforced if the parent also signs the contract.

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LABORATORY FACILITY DESIGN

The National Science Teachers Association (NSTA) recommends a minimum of 80% at the middle school level and a minimum of 40% at the high school level of science instruction time be spent on laboratory-related experiences. Specially designed facilities are required to provide the spaces and materials needed for this instruction. Optimal planning will result in facilities that enhance rather than restrict a program.

Instructional Specifications

The following questions should be answered before an architectural design is attempted.

1. **How will the room be used?** Will it be a dedicated laboratory or a combination classroom/laboratory?

2. **Which sciences will be taught in the room?** Biology, Physics, and Earth Sciences do not have the same requirements as Chemistry.

3. **Will students work in groups?** If so, will the groups be composed of 2, 3, 4 or more students? Is flexibility of grouping desirable?

4. **How many students will be in each class?** NSTA recommends there be no more than 24 students in a laboratory class except in team-teaching or special-needs situations (see p. 7).

5. **How much space is needed per student?** NSTA recommends 5.5 square meters (about 59 square feet) of floor space for combination classroom/laboratories at the secondary level. Four square meters (43 square feet) is recommended for dedicated laboratories. NSTA has no recommendation for general classrooms with no laboratory facilities, but Texas recommends 30 square feet per student and Maryland recommends 35 square feet.

NSTA suggests minimum storage space of 15% of the laboratory space served; preparation and office space would be in addition to student or storage space.

6. **What arrangements will be made for students with disabilities?** Each laboratory should have at least one station designed for use by disabled students. Look for height-adjustable lab stations. The student with disabilities should not be isolated from other classmates. Aisles, doors, and safety equipment should be easily accessible. See page 7 for guideline resources.

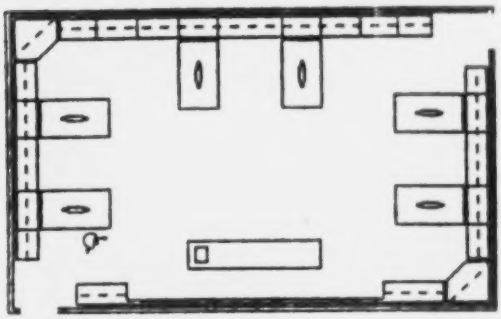
7. **What are the technological requirements?** Plan for future needs for optimal number of computer workstations and networks, telephones (intercom features, videophones, speakerphones), televisions (videos, closed-circuit television, distance learning, media retrieval), etc.

Laboratory Design

Talk to teachers in other districts who have recently remodeled, built new facilities, or are known to have exemplary facilities. Visit several different school science laboratories/classrooms. Vendors can supply the names of districts who have recently purchased their products, and most are very willing to provide drawings of possible room designs for review. Several scientific companies have planning packets with checklists, sample layouts, planning guides, and other helpful information. (See suggested resources at the end of this section.) Evaluate each type of design for effective sight lines (make sure there are no blind spots), traffic patterns and work space, access to storage, and access to safety equipment. The project architect must be familiar with local construction codes.

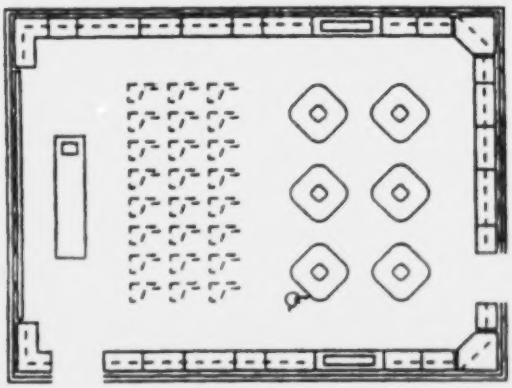
1. **The peripheral or perimeter laboratory design** may be adapted to dedicated laboratory use or combination classroom/laboratory design. This plan provides good instructor visibility for whole class instruction, good traffic flow, easy evacuation, and minimal wall or floor penetration for utilities (which can be run along the wall in a groove behind the base cabinets). Peripheral lab stations provide easy storage in base and wall cabinets. However, if units are on opposing walls there may be some supervi-

sion difficulty during lab activities. This design may be adapted for any science course.

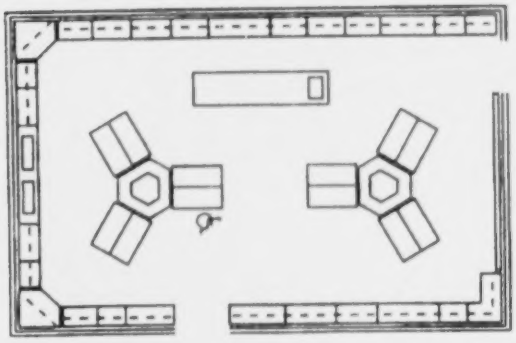


Four-student peripheral design

2. **The island design** is good when lab stations may not be placed next to walls because of windows, doors, other countertops, fume hoods, etc. Larger rooms are usually required to ensure safe traffic flow.

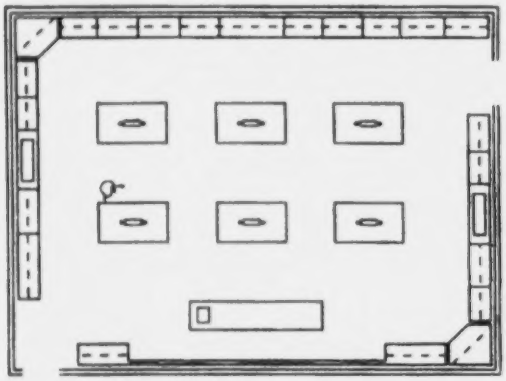


Four-student island design

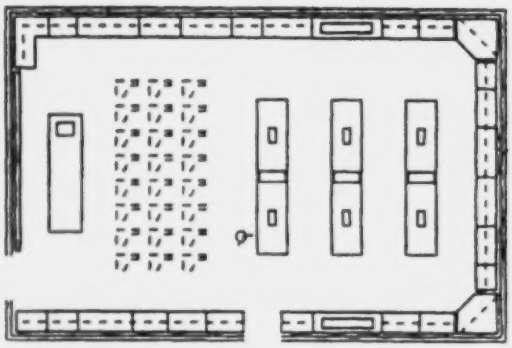


Twelve-student island design

3. **The row design** is another option when wall space is not available. It can require fewer floor penetrations for utilities than the island design, but does reduce student visibility for teachers and limits easy access for helping students. Row design laboratory units may be arranged for 4, 8, or 12 students.



Four-student row design



Eight-student row design

Other considerations in lab design

1. Read through the remainder of this manual to be familiar with safety guidelines concerning eye wash stations, safety showers, utility shut-off valves, ventilation, ground fault circuit interrupters, and other safety considerations.

2. Science rooms should have more than one exit so that if one is blocked, evacuation is still possible.

Missouri Division of Labor Standard 292.070 requires that the doors open outward, and that none can be locked during hours of "labor."

3. Each laboratory may have a separate storage room or there may be one central storage location which is easily accessible to all biology classrooms, all chemistry classrooms, etc. Remember that chemicals may be damaging to mechanical equipment (such as that used in physics).

4. All storage spaces should have locks, and the teacher should have a room master.

5. Wood cabinets are more expensive, but will last considerably longer than laminates. This is particularly true in chemistry laboratories. Countertops of natural stone or black epoxy resin will last much longer than plastic laminates or welded fibers.

6. A demonstration table should be equipped with all utilities, including hot water. A large sink is very helpful.

7. Give the architect and engineer specific information regarding types of materials and equipment to be used in each area so that an appropriate ventilation system may be designed. Missouri Division of Labor Standard 292.110 requires that "establishments in this state shall be so ventilated as to render harmless all impurities, as near as may be."

8. Science classrooms, especially biology and earth science, should have windows and easy access to school grounds or outdoor learning centers. However, window-darkening equipment is needed for showing videos or slides, experimenting with light, photochemical processes, etc. Any room without windows (including storage rooms) should have emergency lighting in case of disrupted power.

9. Laboratory floors should be easy to clean. Carpet helps to reduce overall noise, but a hard surface such as vinyl tile provides easier cleanup and limits retention of chemicals, fumes, and microorganisms. Carpet should *never* be used in chemistry labs.

10. Clustering all science rooms in one general area helps to limit costs for utilities and ventilation.

Laboratory Planning Services

The following companies provide laboratory planning services and/or furniture. The list is not all-inclusive, and suggestions from other sources should be considered.

Flinn Scientific, Inc.
1-800-452-1261

Kewaunee Scientific Equipment Corporation
(704) 873-7202
Missouri dealer: Glen Alspaugh Co.
(314) 993-6644

Leonard Peterson & Co., Inc.
(334) 821-6832
Missouri dealer: Mid-State School Equipment Co.
(816) 246-8600

Sargent-Welch Scientific Furniture Dept.
1-800-678-LABS
1-800-SARGENT

Sheldon Division, General Equipment Manufacturers
(601) 892-2731
Missouri dealer: Hoover Brothers
(214) 634-8474

Taylor Division, American Desk
(512) 352-6371
Missouri dealer: Bowlus School Supply
(316) 231-3450

LAB SAFETY EQUIPMENT AND ACCIDENT RESPONSE

Eye Protection

Missouri law requires the use of ANSI approved eye protection ("Z87" imprinted on all parts) for everyone in any situation where there might be a hazard.

Safety Eyewear

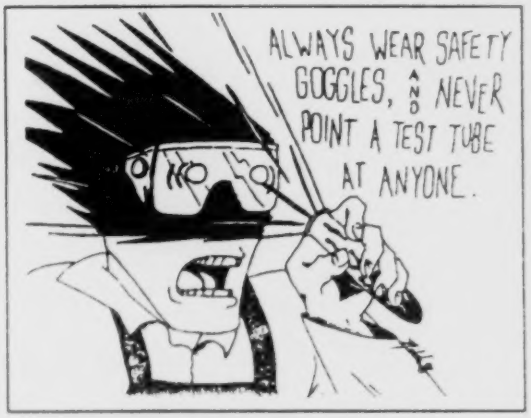
Industrial quality eye protection is required for students, teachers, and visitors by Missouri law (Section 170.005). This protection is required for participation or observation in any chemical or physical school laboratory involving caustic or explosive materials, hot liquids or solids, injurious radiations or *other hazards not enumerated*. The entire statute may be read on page 6. Due to the "other hazards not enumerated" clause of the law, the need for eye protection should be evaluated for every activity, and required for any activity involving chemicals (including preserving and staining of biological specimens), flames, pressure, projectiles (including centripetal devices, cutting glass, grinding or chipping rocks), and hazardous radiation (including use of infrared and UV light or lasers; there is no approved eye protection for direct viewing of the sun). If there is any question of safety, require eye protection.

Safety goggles are needed for protection from chemical splashes. The two styles of goggles which are most suitable are type G (without ventilation) and type H (with indirect ventilation). Both types fit closely to the skin and will protect from splashes of liquids from all directions. Face shields may be needed in some situations in addition to the goggles.

Prescription glasses do not provide enough protection; goggles may be found which fit over most glasses. The wearing of *contact lenses* in the laboratory is not recommended by the American Chemical Society (ACS) or the National Society to Prevent Blindness as they may trap chemicals against the cornea and cause further harm. Soft contact lenses can absorb and retain chemical vapors. If contacts are worn, non-vented safety goggles are essential. The contacts should be immediately removed if redness of the eye, blurring of vision, or pain in the eye occurs while in the laboratory. Taking contacts out immediately before a lab is not recommended, as the eye will have molded to the contact lens and will need at least one hour to return to normal vision. It is very important that all students wash their hands before leaving the laboratory and especially important for students wearing contact lenses.

Safety glasses are more resistant to high impact and recommended for use where projectiles may be encountered. Even with side shields, these glasses are not sufficient protection against chemical splashes and are not recommended for use with chemicals.

Missouri law requires that eye protection meet the standards of the American National Standard Practice for Occupational and Educational Eye and Face Protection *(ANSI)*. All approved eye wear will have *"Z87"* stamped on each section. Laboratory catalogs mention "ANSI approved" if the standards are met. The manufacturer's trademark on the eyewear is not proof of ANSI approval.



Sanitizing Protective Eyewear

A germicidal ultraviolet (UV) cabinet is one method for sanitizing eyewear. The 5- to 15-minute cycle (follow the manufacturer's recommendations)

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will disinfect susceptible bacteria and viruses from surfaces, though the Missouri Department of Health questions whether disinfection is total. The Missouri Department of Health recommends that the UV lamp intensity be checked yearly with a UV meter and the lamp be cleaned weekly or biweekly as the lamp intensity is affected by the accumulation of dust and dirt on it.

UV cabinets are expensive, and the time needed for disinfection is not always available. However, some type of sanitizing should be done after each student use.

The Missouri Department of Health, Bureau of Communicable Disease Control, recommends the following alternative for the cleaning and disinfection of goggles:

1. Mix one tablespoon of household bleach (5.25% hypochlorite) with one quart of water. This solution equals 800 ppm available chlorine and needs to be made fresh daily.
2. Clean the frame and lenses of the goggles with a few drops of liquid detergent on a paper towel. Rinse the goggles well with water and wipe the goggles partially dry with a paper towel.
3. Dip the goggles into the bleach solution OR wipe them with a cotton ball or gauze pad saturated with a 70% isopropyl alcohol solution. Let the goggles air dry.
4. Additional care is needed if a student has an obvious infection of the eyes (or has had an eye infection within the last 10-14 days), face, scalp, or hands, is known to be a carrier of a disease transmitted by blood or serum (such as HIV or hepatitis), or has an upper respiratory infection. The student should wash his/her hands for at least 30 seconds prior to and after cleaning the safety goggles. The goggles should be immersed in the chlorine solution for 10 minutes following the initial cleaning as described in step #2. This chlorine solution should be discarded, and a fresh solution used for other student goggles.

Eyewash Stations

Eyewash fountain stations are needed in any area where chemicals are used.

Immediate first aid treatment is required for any eye injury, including any exposure to a chemical. An eyewash station should be located in any room where there are chemicals, including classrooms and storerooms, within 15 seconds travel time of any student or teacher.

A plumbed eyewash, possibly in combination with a face-wash or shower, is preferred. If not available, a converter for a sink faucet is acceptable but adaptation will need to be made to ensure immediate safe water temperature and pressure and to prevent contamination by other use. Squeeze bottles containing boric acid or a buffer solution are *not* an acceptable alternative and may in fact result in serious eye injury. They do not contain enough liquid to be effective, can treat only one eye at a time, and after a time can become contaminated with bacteria.

Guidelines for eyewash station selection

1. The eyewash should treat both eyes at the same time.

2. Water should be available immediately with no delays for lengthy conversions or regulation of temperature or pressure.

3. Water temperature should be close to 32-35° C (90-95°F) to prevent shock or damage to tissues.

4. The eyewash should be capable of producing a gentle flow of water for 15 minutes (at least 3.0 gal/min at 30 psi - ANSI Z358.1 Standard).

5. The eyewash station should leave hands free to hold eyelids open.

6. The eyewash station should be adaptable for use by students in wheelchairs.

If a normal faucet is adapted, it is helpful to maintain a steady stream of water through the eyewash throughout the lab period, so that the water is at a safe temperature and pressure. Students should have safety partners so that one may assist the other to the wash station and help with its use. Any eyewash unit should be flushed weekly for three minutes to prevent backup of gases and buildup of bacteria in the plumbing lines, and records should be kept of this maintenance. Portable eyewash/drench hose tanks are available, but most models only deliver about 8 gallons of water and should not be considered as a permanent eyewash station or safety shower.

Use of Eyewash Stations

1. Begin washing the face, eyelids, and eye for at least 15 minutes as soon as possible. The eyelids should be held open, rotating the eyes as much as possible to ensure removal of the chemical.

2. Contact lenses, if worn, should be removed immediately if at all possible. Continue flushing even if contacts cannot be removed.

3. If the student is lying down, gently hold the eyelids open and pour water from the inner corner of the eye outward. Do not allow the chemical to run into the other eye.

4. In the case of an alkaline burn or any other serious eye injury, immediately send for an ambulance so that first aid will not have to be discontinued during transport to medical facilities.

5. Test the function ability of the eyewash station on a regular basis and keep a record of inspections.

Safety Showers

Hand-held water sprayers should be readily available for flushing chemicals off of all parts of the body.

A deluge shower is good for major spills, but a hand-held water sprayer with a 6-foot hose is suitable for small spills and may also function as an eyewash station if nothing else is available. This shower should be accessible in no more than 10 seconds (ANSI Standard Z358.1-1990), with water mains turned on. Too often the water is shut off to prevent vandalism, making the shower useless in an emergency. A plumbed unit should be capable of delivering 30-60 gallons of 15-35°C (60-95F) water per minute, while a hand-held drench unit must deliver at least 3 gallons per minute (ANSI Z358.1 Standards).

Another advantage to the hand-held shower is the ease of use by handicapped students. The hand held sprayer is also useful for flushing chemical splashes on the lower body.

The safety shower should be activated on a regular schedule and a record kept of the testing.

Use of the Safety Shower

1. Begin use of the shower as soon as possible, removing any contaminated clothing while in the shower (have large towels or lab coats available for privacy).

2. The victim should remain in the shower for a minimum of 5 minutes, washing the skin with water or with soap and water for some organic chemical splashes. Cooler water is fine; it slows chemical reactions and is good first aid for burns.

3. Avoid use of neutralizing solutions unless recommended by medical personnel.

Fire Safety

The National Fire Protection Association places a school science laboratory in the "extra high risk" category. Plan for prevention, then plan and practice emergency procedures. The primary goal of fire safety should be prevention by controlling the three components of fire: combustibles, oxidizers, and ignition sources.

To Reduce Combustibles:

1. Keep the lab and storage areas clean. Limit the amount of paper, wood waste, clothing, and other easily ignitable materials.

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2. Limit the quantities of flammable and combustible chemicals in the work area to the amount actually needed; chemical storage containers should not be in the work area. For example, do not leave the can of alcohol nearby after filling burners.

3. Store flammables separately from other substances, preferably in a safety flammables cabinet. Do not store them in a household-type refrigerator.

To Control Oxidizers:

1. Limit air flow from open windows and doors when working with flammables. However, adequate ventilation is a priority when working with any toxic substances.

2. Work carefully with oxidizing agents. Chlorates, nitrates, or peroxides and other oxidizers should not contact combustible substances.

To Reduce Ignition:

1. Evaluate the use of open flames in the lab. Never use open flames near flammable liquids (such as for heating an alcohol), or near combustible gases. Whenever possible, use hot plates with flat tops (instead of coils) in place of open flames.

2. Carefully maintain all electrical equipment, including cords. Discontinue use of any equipment in need of repair.

3. Store any source of ignition separately from other ignition sources or combustible materials. Ignition sources include matches, lenses, and parabolic mirrors.

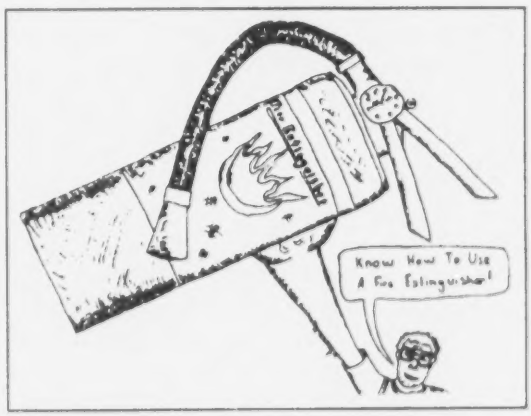
4. Stress the importance of responsible student behavior when working with an open flame. Students should stay in their immediate work area, keep the work area as clear as possible, and not put any unauthorized materials into the flame. Long hair and loose clothing should be controlled.

Preparation for Fire Emergencies

1. **All aisles and exits must be clear and accessible.** There should be at least two possible exits.

2. **Practice emergency fire response.** Students should understand the priority *stop, drop, and roll* technique for putting out clothing fires. A fire blanket may be used (see fire blanket section). Do ***not*** use a fire extinguisher on a person as serious chemical burns or frostbite can result.

3. **Have appropriate fire extinguishers, detectors, and alarms in the classroom, and know how to use them.** Place fire extinguishers near an escape route, not in a "dead end." Check the extinguishers periodically and maintain them at full charge; keep maintenance records. The local fire department may be willing to conduct a fire safety class for teachers which would include training in the use of fire extinguishers, especially during Fire Safety Week. Dry, clean sand is a good fire extinguisher for small fires, especially those involving flammable solids.



4. **Student safety is the most important responsibility of the teacher**. In a serious fire, evacuate the students, sound the fire alarm, shut off master switches in the classroom for gas and electrical power (if available), close windows and doors if possible, and then determine if it is feasible for the teacher to try to put the fire out. If the fire is spreading or could block the escape route, leave immediately and let professionals fight the fire.

Fire Extinguishers

There are four classifications of fire:
1. Class A - wood, paper, cloth
2. Class B - flammable liquids
3. Class C - electrical
4. Class D - combustible metals (Mg, Na, K, etc.)

1. **Water is fine for Class A fires.** It should never be used for Class B, C, or D fires.

2. **Dry chemical Class ABC fire extinguishers are recommended for use in the science classroom.** This type of fire extinguisher can be used for the three major classes of fires: paper/wood, grease/alcohol, and electrical.

3. **Dry sand works well for <u>small</u> fires from metals.** Class D powder extinguishers are available; NEVER try to put a combustible metal fire out with water. Some of the metals react violently with water.

4. **Select an appropriate size extinguisher for the room area to be covered.** Fire extinguishers have a UL rating on the label which defines their limits. For example, 2A:40B:C means the extinguisher is adequate for 2 square feet of a Class A fire, 40 square feet of Class B, or may be used for Class C fires.

5. **Consider automatic overhead fire extinguishers for the chemical storage room**. The extinguisher heat link will melt at high temperatures (generally 135-165° F) and activate the extinguisher. A small automatic extinguisher is also a good idea for the flammables cabinet.

6. **Carbon tetrachloride (CCl_4)** fire extinguishers may still be stored in some older schools. They should never be used; CCl_4 is toxic and in a fire it can form phosgene, which is even more toxic.

Fire Blankets

1. **Asbestos blankets should be replaced with fire blankets made of wool.** Asbestos is a known human carcinogen.

2. **Fire blankets may be used to smother a small fire.**

3. **A clean fire blanket is useful for keeping an accident victim warm to help prevent shock.**

4. **There is concern about using a fire blanket to wrap a person when clothing or hair is on fire.** It is possible that the blanket will hold the heat next to the body, increasing the possibility of burns. This heat may increase the melting of synthetic materials onto the skin. The stop, drop, and roll method may still be the safest in most situations.

5. **If a fire blanket is used to wrap a person when clothing or hair is on fire, the blanket must be used correctly.** A folded fire blanket stored in a case should be spread on the floor so that the student may wrap it around the body as he or she rolls. Another type of fire blanket unrolls from a vertical wall case as the student wraps the blanket around the body. The student should lie on the floor as soon as the blanket leaves the case to prevent a blanket "chimney effect." The blanket should be held closely at the neck to force flames away from the head.

First Aid Kits

A first aid kit should be kept in each classroom.

The teacher should have the necessary supplies on hand so that first aid may be given until the school nurse or other medical help is reached. This kit need not be extensive, but should contain gloves for dealing with body fluids (disposable latex gloves are good and are available from the school nurse or a medical or dental supply company), bandaids, an antiseptic with applicators, sterile gauze pads, and first aid tape. See page 24 for further first aid information.

Spill Kits

Materials for containing and cleaning up chemical spills should be readily accessible. Absorbent materials include spill pillows, spill mats

or pads, clean dry sand (which is also useful as a fire extinguisher for small fires), and clean cat litter. A fire blanket is useful for containing and absorbing liquids. An inert-bristle broom (such as polypropylene), plastic and metal dust pans (depending on the reactivity of the chemical), large sealable plastic bags, and a disposal container with lid will also be needed. Protective clothing (goggles, gloves, lab coats, and possibly shoe coverings) should be easily available.

Mercury, which is volatile and highly toxic by inhalation and absorption, requires special clean-up materials. Spill control kits, which include sprays to reduce mercury vapor, mercury sponges, and safe storage containers for the waste, are available from several science supply companies. These kits provide the best protection in the event of a mercury spill. Whenever there is an accident with mercury, provide maximum ventilation and avoid all contact with skin, clothing, or shoes. Do not sweep the mercury with a broom, as this creates more vapors and contaminates the broom. If a commercial spill kit is not available, push the pools of mercury together with a disposable towel and pick up the mercury with a medicine dropper or bulbed pipette. Transfer the mercury to a seamless polyethylene or polypropylene bottle for regulated disposal. If preferred, the mercury may be sprinkled with zinc metal dust to form an amalgam, which is more easily collected than elemental mercury. Care must be taken with zinc metal dust, as it expands when damp and may explode a container. A mercury sponge, which contains zinc fibers, is useful for final mercury cleanup. Wipe down all surrounding areas, as mercury tends to splatter. Remember that all materials exposed to the mercury (towels, etc.) are now considered hazardous waste. Never use a standard vacuum cleaner to clean up mercury as it will spread vapor throughout the area.

Fume Hoods

A functioning fume hood controls toxic or flammable vapors, and serves as a barrier between a lab worker and the chemical reaction. It is not a means of chemical disposal or a place for storage of chemicals. Fume hoods are not designed for general room ventilation.

Stationary or portable fume hoods should be used whenever there is the possibility of hazardous vapors or gases being used or produced. Many substances are toxic by inhalation, with toxicity related to potency as well as length of exposure. The teacher who is in the classroom for many hours daily over an extended period should be especially conscious of the importance of good ventilation.

Fume Hood Efficiency

1. Measure fume hood velocity with an air flow meter. These meters are available from several lab supply companies. Face velocities should range from 60 to 100 cubic feet per minute (fpm).

2. Use the sash as a face shield (in addition to goggles). Never work with the sash wide open or above chin level.

3. Work as far inside the hood as practical, never less than 6" from the front edge. Keep the head out of the hood.

4. Locate hoods away from doors, windows, and air vents for maximum efficiency. ANSI Z9.5 regulations state that hoods should not be closer than 10 ft to a door or placed on a main aisle.

5. Fit hoods with condensers, traps, or scrubbers to collect wastes and to inhibit their release into the atmosphere.

6. Do not use the hood for storage of excess or waste chemicals. If a fire or accident does occur in the hood, every chemical stored in the hood would be involved.

Ventilation and Exhaust Systems

The science rooms should have a ventilation and exhaust system which is independent of all others in the school building and not interconnected between science rooms. The purpose of these systems is to remove odors from the science classroom directly to the outside of the building.

1. The ventilation purge fan in each laboratory should remove at least 3200 cubic feet of air per minute, so there is a complete room air change possible in five minutes. These fans are not intended for continual use, but need to have an on/off switch to be used as needed.

2. Fumes should *not* be vented near air intakes.

3. Ductwork, especially that leading from the chemistry rooms, should be made of or lined with noncorrodible material.

Gloves and Aprons

Chemical and heat resistant gloves should be available, as should gloves for handling rough or sharp materials. Lab aprons should be worn by anyone working with chemicals.

Gloves

1. No one kind of glove is suitable for all situations. Consult the Material Safety Data Sheet (MSDS) for a chemical if there is any question about which type of glove gives the best protection.

2. Check the manufacturer's recommendations as well as MSDS's before deciding which type of glove to select. Generally, nitrile gloves are more resistant to acids and organic solvents than rubber or neoprene and last longer than polyethylene gloves.

3. Discard any glove with holes or cracks; a chemical diffusing through a glove is held against the skin, increasing exposure.

4. Wash and remove gloves before leaving the lab or handling objects such as doorknobs, telephones, texts, etc.

5. Avoid any gloves which contain asbestos. Heavy gloves meant for handling hot objects or glassware usually have poor chemical resistance, and asbestos is a carcinogen.

Aprons

Many types of aprons are available. Ask for free samples from the supplier for comparison of quality of construction.

1. The American Chemical Society has found polypropylene aprons to be strong, resistant to most chemicals, and lightweight. Plastic aprons are resistant to corrosive chemicals and are lightweight, but may be ignited by flammable solvents as static electricity accumulates in the apron.

2. Lab aprons should be worn whenever a person is working with chemicals, and are especially important protection for any student who may not be able to react quickly to a spill or splash. The apron should be tied closely to the lower part of the neck and should be long enough to cover at least to the knees.

Refrigerators

Household-type refrigerators should not be used for storage of chemicals because of the possibility of explosions and fires.

Cold storage is often recommended for storing flammable materials such as organic solvents and for storage of biological specimens. The different control switches and defroster heaters in a normal refrigerator can spark, igniting flammable materials and causing fires and/or explosions. A trained technician may modify a refrigerator by removing all internal sources of spark, but the other electrical parts on the outside of the refrigerator can still ignite fumes in the room or leaks from the refrigerator. *"Explosion proof" refrigerators* have modified internal wiring and sealed motors and switches. They should meet National Fire Protection Association standards.

If used for storage of radioactive materials, the refrigerator should have the standard radioactivity symbol on the door and be checked periodically for radioactive contamination.

Food should not be stored in the science storage refrigerator.

General Housekeeping

There is a relationship between safety and orderliness in the science laboratory. The following is a partial listing of housekeeping guidelines:

1. **Work areas should be kept clean and free from obstructions.** Cleanup should follow the completion of any operation or at the end of the day.

2. **Wastes should be deposited in appropriate receptacles.**

3. **Spilled chemicals should be cleaned up immediately and disposed of properly.**

4. **Stairways and hallways should not be used as storage areas.**

5. **Access to exits, emergency equipment, controls, etc. should never be blocked.**

6. **Equipment and chemicals should be properly stored so that clutter in minimized.**

Earthquake Preparedness

Many Missouri school science laboratories would be affected by an earthquake in the New Madrid area. The following suggestions are from Stanley Pine, chemistry professor at California State University - Los Angeles.

1. **All storage shelves and cabinets should be securely attached to the walls.**

2. **Electronic balances, spectrometers, and other similar equipment should be attached to the lab bench.** Dr. Pine recommends Velcro straps if the equipment is often moved or clear silicone sealant placed on the feet of the equipment and sealed to the bench. This sealant can be easily cut away when the equipment must be moved.

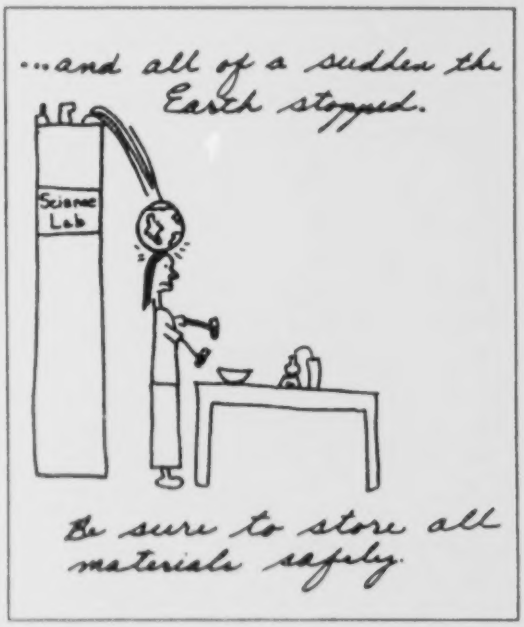
3. **Chemical shelving should have restraints to contain the chemicals.** One-two inch wooden edge lips are acceptable, or stretch cords or 1/8-inch stainless steel rods anchored to the individual shelves and set about two inches above shelf level are adequate.

4. **All cabinet and refrigerator doors should have secure closing devices.** In California, many doors with older magnetic locks did not remain closed.

5. **Larger equipment and larger chemical containers should be stored on lower shelves.**

6. **Compressed gas cylinder supports must be securely anchored, preferably by bolting to a solid wall or bench.** Turn-screw compression clamps are inadequate. Restraint straps should be non-flammable.

7. **Have an evacuation plan, including responsibilities for shutting off laboratory utilities.**



FIRST AID

According to the National Safety Council, about 5000 science-related accidents occur each school year. More accidents happen in grades 7-9 than in grades 10-12. The majority of the accidents are cuts and burns to the thumb and index finger.

First aid is the immediate care given to a person who has been injured or suddenly becomes ill. Its purpose is not to treat but to protect, and it is used when medical help is not immediately available. A teacher has a responsibility to know what to do if a student is injured or becomes ill while under the teacher's care. *First Aid: Responding to Emergencies* (stock #650005) from the American Red Cross is an excellent reference and is available from local chapters. The Missouri Department of Health also has a *Recommended Procedures for Emergency Care of Illness and Injuries* flip chart which was specifically developed for school use (see page 66 for address). A first aid course with CPR training should be a priority for all teachers. The Missouri Department of Health strongly recommends that at least one and preferably two members of a school's permanent staff receive formal first aid and emergency training. The Missouri Good Samaritan Law offers limited protection for those who are trained in recognized first aid and CPR programs.

In Case of an Accident

It is essential to obtain medical help in every case of serious injury or illness, in all cases of injury to the eye, and whenever in doubt. A teacher should not diagnose, treat, or offer medication, but may offer the necessary first aid until medical help is obtained.

1. **Keep calm.** Keep others from crowding the injured student.

2. **Send the designated student(s) for the school nurse (if your school has one) and/or the principal.**

3. **Restore breathing.** Use mouth-to-mouth respiration, CPR, or a method to stop choking *if you have had appropriate training*. It is possible to cause further damage to the student, which is why first aid training is vital. Names of persons certified in CPR should be posted in every classroom or laboratory.

4. **Stop any bleeding by applying a light pressure.** Wear protective gloves, and see page 28 for more information.

5. **Prevent shock.** Have the student lie down, cover him/her with a blanket (a clean fire blanket is fine), and elevate the feet a few inches if the face is pale and there are no head, neck, or chest injuries. *Symptoms of shock* include cold or clammy skin, pale face, chills, increased pulse, nausea or vomiting, and shallow breathing. Don't give the student anything to drink or eat.

6. **Contact the parent or guardian as soon as possible.** Good communication will increase understanding and limit additional complications.

7. **File an accident report form whenever there is any injury to a student and/or property damage.** Most schools have a standard form which should contain information regarding the date, time, and place of accident; student name, age, and address; a complete description of all details of the accident including any equipment, chemicals, organisms, or materials involved; a description of the nature of the injury and/or property damage; names and addresses of witnesses; the name and address of the teacher and person submitting the report; and the signature of the principal. Keep a copy of the completed report for your files.

The Handling and Disposal of Body Fluids

Many infectious agents may be found in the blood and body fluids of humans, even if there is no outward symptom of infection. Routine safety

procedures should be adopted by everyone in contact with blood, semen, drainage from scrapes and cuts, feces or stool, urine, vomitus, respiratory secretions, and saliva. Follow your school policy regarding the handling and disposal of body fluids. The following general guidelines may also be helpful.

Handling Body Fluids

1. **Avoid direct skin contact with body fluids.** Persons with any open skin lesions should take particular care to avoid direct exposure of the lesions to body fluids. If it is not possible to avoid contact, wash hands vigorously for 10-15 seconds with a disinfecting soap and running water.

2. **Use disposable gloves when direct hand contact with body fluids is necessary.** For example, a student with a bloody nose or cut should be handed a paper towel or tissue until gloves can be put on. Latex or vinyl gloves are good and are available from some science laboratory catalogs or any medical or dental supply house. The disposable gloves should be removed without soiling the hands and should be disposed of in an impervious plastic bag. If reusable rubber gloves are used, they should be washed with disinfecting soap and running water for 10-15 seconds prior to removal.

3. **Keep gloves in accessible locations.** This includes teachers' desk drawers, first aid kits, the school office, and health offices.

4. **After removing gloves, wash hands for 10-15 seconds with a disinfecting soap and running water.**

5. **Clean any surface which has been in contact with the fluids with an EPA-approved disinfectant such as Lysol or a freshly made 1:10 dilution of household bleach** (made by using one part bleach to ten parts of water).

Caution: Any EPA-approved disinfectant used should be diluted according to the manufacturer's instructions. It is not appropriate or necessary to add more disinfectant than the directions indicate. Doing so will make the disinfectant more toxic and could result in skin damage to those individuals using it. A diluted bleach solution should not be mixed with any other chemicals as a toxic gas may be produced.

Disposal of Body Fluids and Cleanup Supplies

Gloves, paper towels, absorbent floor sweep material, and other supplies used in the cleanup should be disposed of in a closed plastic bag. According to the Centers for Disease Control, infective waste should be either incinerated or autoclaved (sterilized by heat) before disposal in a sanitary landfill. A school janitor should be familiar with the procedure for your district.

For current facts on AIDS, contact the Missouri Bureau of AIDS Prevention at 1-800-533-2437, the Missouri Department of Health at (573) 751-6400, or the National AIDS Hotline at 1-800-342-2437. The National Hotline also offers classroom conference calls through which student questions may be answered. These calls should be arranged with the Hotline in advance so that the education specialist will be available.

FIRST AID RESPONSE

POISONING

Toxic substances may enter the body by inhalation, ingestion, injection, or skin contact. According to data from the American Association of Poison Control Centers, about 3,000,000 poison exposures will occur in the U.S. in the next 12 months; 1.0% or about 30,000 will happen in schools. If a poisoning occurs and medical assistance is not immediately available, call one of the Poison Control Centers (phone numbers listed inside the front cover and on page 65). Syrup of Ipecac should always be available from the school office or nurse, but should be used only on the advice of the Poison Control Center or physician.

The person calling for medical assistance should know the victim's age and weight, the poison involved (if possible, have the label with you when

you call), the amount taken, if any first aid has being given, if the victim has vomited, and how long it will take you to get to the hospital. Remain calm.

Inhaled Poisons

1. Call for medical assistance.

2. Carry the victim to fresh air if possible. If the victim is too large to carry, open all doors and windows.

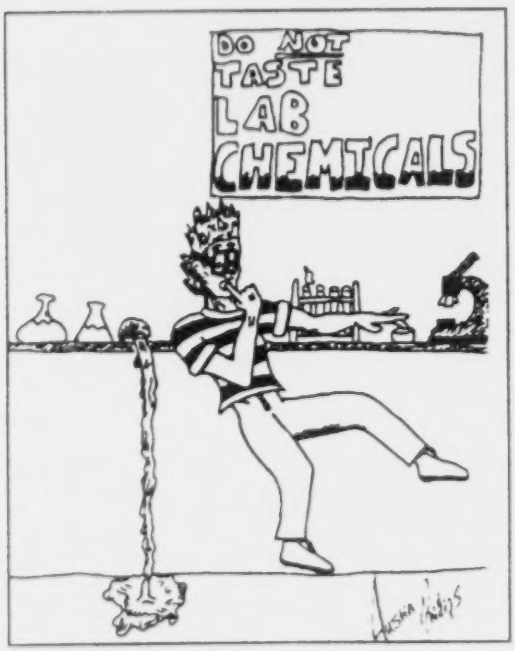
3. Begin artificial respiration if the victim is not breathing, if you are trained to do so. Care should be taken not to inhale the victim's breath.

4. Treat the victim for shock until medical assistance arrives.

Ingested Poisons

1. Call for medical assistance.

2. Maintain the victim's breathing.



3. Do not administer Syrup of Ipecac to induce vomiting, or water or milk for dilution of the poison, unless advised to do so by a physician or the Poison Control Center.

4. Take the container of poison to the medical facility.

Injected Poisons

Call for immediate medical assistance if any chemical substance is injected. See the following page for the section concerning bites and stings from animals.

Skin Contact Poisons

1. Remove contaminated clothing as soon as possible if contact is made with a plant poison (such as poison ivy oils). Wear rubber gloves if you are helping a student. Immediately wash all exposed areas with large quantities of soap and water.

2. See the following sections about chemical burns of the skin and eyes.

CHEMICAL BURNS - SKIN

1. Wash away the chemical with large amounts of water as quickly as possible and for at least five minutes.

2. Remove any clothing contaminated with chemicals; wear rubber gloves.

3. *Do not attempt to neutralize the chemical unless approved by medical personnel* and the chemical is first diluted with water. The skin is not the place for a chemical reaction.

4. Apply a sterile dressing (not fluff cotton) and get medical aid.

CHEMICAL BURNS - EYES

If the chemical is a strong corrosive, irritant, or toxic, immediately send for an ambulance so that

first aid will not have to be discontinued during transport to medical attention. This is especially important for strong alkali (such as sodium hydroxide) burns.

1. As quickly as possible, begin flushing the affected eyes, eyelids, and face for several minutes, and for at least 15 minutes in the case of corrosive chemicals. The victim should hold the affected eyelid(s) open and continuously roll the eyes up, down, right, and left. If the student is wearing contacts, they should be removed if at all possible.

2. In the case of corrosive chemical contact, an eyewash fountain must be reached within 30 seconds. If the eyewash fountain or hose is attached to a regular faucet, make sure the water is not too cold or too hot or under too much pressure. If an eye wash station is not available, have the student lie down with his/her head to the side, and while holding the eyelid open pour lukewarm water from the inner corner of the eye outward. Make sure the chemical does not wash into the other eye. It is a good idea to have clean bottles of water in the classroom which are saved for this specific purpose. If both eyes are affected, have the student lie on his/her back and be very careful not to allow runoff from one eye into another.

4. Cover the eye with a dry, clean dressing (not fluff cotton). Caution the victim not to rub the eye.

5. Contact a physician if any symptoms such as redness or irritation to the eye occur. Get immediate medical assistance if a strong irritant, corrosive, or toxic chemical is involved. Contact the student's parent or guardian.

HEAT BURNS

Minor Burns

1. Place the burned extremity into cold water or apply clean, cold, moist towels. Do not use ice or salt in the water. Maintain treatment as long as pain or burning exists.

2. Apply a clean, dry dressing if needed. Ointments and salves prevent the release of heat from the skin, and should not be used unless prescribed by a physician.

Major Burns

1. Lay clean towels over the area and pour cold water over the towels. Do not add ice or salt to the water.

2. Gently blot the area dry. Do not break blisters, remove tissue, or apply any ointments, sprays, or salves.

3. Cover the burned area with a clean, dry cloth to protect it. If arms or legs are affected, keep them elevated.

4. Seek immediate medical care.

ELECTRICAL BURNS AND SHOCK

1. Disconnect the power source if possible or pull the victim away from the source using dry wood or a length of dry cloth. Make sure the rescuer has dry hands and is standing on a dry floor. Do NOT use a conducting material such as a metal object to attempt to remove the victim from the power source.

2. Maintain breathing.

3. Treat for shock symptoms (keep victim lying down, cover with blanket, elevate feet a few inches if no chest or head injuries).

4. Seek medical help as soon as possible. All electrical burns should be evaluated by a physician.

SEVERE BLEEDING

1. Send for emergency medical help.

2. If possible, put gloves on. Place a thick pad of clean cloth directly over the wound and press firmly with the palm of the hand to control blood flow. Do

not apply a tourniquet unless you are trained to do so, and as a last resort to stop bleeding.

3. Do not disturb blood clotting by removing saturated cloth; apply additional layers.

4. Do not use any topical medications.

5. Treat for shock until medical help arrives.

BITES AND STINGS

Snake Bites -If possible, identify the snake which bit the victim. Antivenom is species specific.

1. Keep the victim calm and as quiet as possible, with the bitten area at or below heart level if possible. For example, if the hand is bitten, keep it lowered at the side of the body, not high up on the chest.

2. Transport to a hospital or medical aid promptly.

3. If the hospital can be reached within an hour and no symptoms develop, no further first aid is necessary until the victim arrives at the hospital.

4. Do NOT use constricting bands unless medical help is more than an hour away and mild to moderate symptoms such as pain and swelling occur. Check a pulse in the extremity to be sure all blood flow has not stopped. Incision/suction is not recommended. If severe symptoms such as paralysis or loss of consciousness occur, apply a tourniquet, elevate the extremity, and keep the victim quiet. If you are going to be in an area where snakebite is possible and medical help is distant, contact the local Red Cross for training in the use of a snake bite kit.

5. Do not administer aspirin, sedatives, or apply cold compresses or ice.

6. Notify the parents of the victim regarding the bite.

Spider Bites

1. If a person is bitten by a black widow or brown recluse spider, seek immediate medical attention. Keep the victim calm, quiet, and warm. Do not apply ice.

2. Other spider bites generally need no treatment other than the application of a soothing lotion such as calamine. However, the student should be observed for any reaction and parents should be notified. See page 59 for more spider information.

Ticks

1. Ticks should not be removed by teachers because of medical legal liability. The parent or guardian should be contacted. The parent or guardian or physician of their choice has the responsibility for removal of the tick.

2. If the victim becomes ill within a week of a tick bite, or other symptoms develop in the bite area, the parent/guardian should contact medical help. See page 59 for more information on tick diseases.

Stings

Be aware of student allergies. Get immediate medical help if the student has a history of allergies to stings from wasps, bees, hornets, or yellow jackets. Approximately 3% of the population may develop a life-threatening anaphylactic reaction to a bee sting.

1. Use ice wrapped in cloth or cold compresses to relieve pain and swelling.

2. Keep the student as quiet as possible.

3. Do not PULL the stinger out; instead, remove it with a scraping motion with a fingernail or plastic card to reduce toxin injection.

4. Wash the area thoroughly with soap and water. Ice may be applied intermittently to reduce pain and swelling, and also to slow the venom absorption. A baking soda/water paste or a soothing lotion such as

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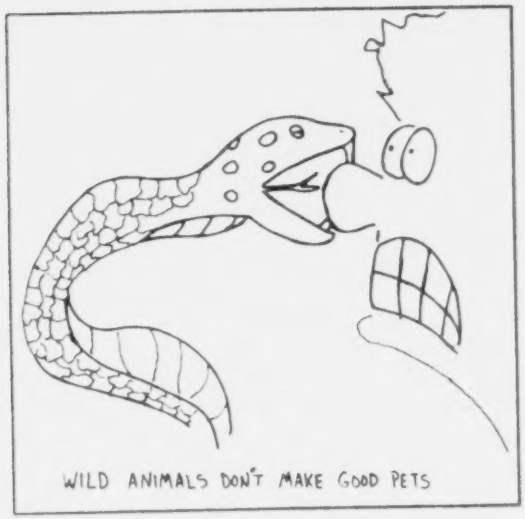
calamine may also be applied to help relieve the pain.

5. Any sting to the throat, mouth or tongue should receive immediate medical attention as swelling of these areas can cut off passage of air.

6. **An allergic reaction to a sting requires immediate emergency medical treatment.** This reaction may be indicated by complaints of abdominal cramps and nausea, coughing, tightness in the throat or chest, swelling and itching of the eyes, or by paleness of skin or excessive sweating.



Mammal Bites

There is danger of infection and rabies from bites of all warm-blooded animals.

1. Wear gloves if possible while cleaning the wound. Wash the wound area thoroughly with a warm soap or detergent solution for several minutes.

2. Apply a bandage if needed.

3. Notify the student's parents or guardians in case follow-up medical treatment is needed.

4. Medical history should be shared if the bite was from another child.

5. Any animal that has bitten a child must be caught and observed for rabies. According to the Missouri Department of Health, the authority responsible for catching, transporting, and caring for the animal varies by city or county. The local police, sheriff, or humane officer should be contacted so that appropriate action may be taken.

LABORATORY EQUIPMENT SAFETY

Laboratory equipment is generally safe when appropriately used. Conversely, almost any piece of equipment may be unsafe if used incorrectly. Laboratory experiences should help students understand and apply general safety measures to every situation. In this section, some safety guidelines will be given for some of the more commonly used lab equipment.

Batteries

Alkaline or dry cell batteries are safest for use in the classroom. Lead storage batteries contain liquid sulfuric acid and have the ability to deliver sufficient current to cause wire insulation to ignite. They should be used with caution in the classroom when a larger DC current is needed.

1. Dispose of all leaking batteries and clean all places the leaking battery has contaminated with soap and water. Batteries should not be incinerated, so probably should not be placed in the trash. Ask the janitor about safe disposal.

2. Do *not* try to recharge any battery not specifically designed to be recharged. An explosion may result.

3. Do *not* try to heat a battery to make it work better. It may explode.

4. Batteries may be stored in a refrigerator to prolong life, though alkaline batteries do not benefit from cold storage. Do not store batteries in drawers where they may loosely roll around.

Centrifuges

Make sure the centrifuge is securely anchored where its vibrations will not cause bottles or equipment to fall.

1. Always close the centrifuge lid during use.

2. Do *not* leave a running centrifuge until full operating speed is reached and the machine is running smoothly without excess vibration.

3. Regularly clean the buckets, centrifuge tube cushions, and rotors. Glass shards or other substances in the cushions are a common cause of tube breakage.

4. Immediately stop the centrifuge if vibration occurs. Check that tubes are symmetrically loaded and contain approximately the same amounts of liquid.

Electrical Circuits

Use low voltage direct current whenever possible.

1. All electrical outlets should be properly wired and grounded. An electrical safety survey of the science laboratory by a qualified electrician may be considered. In new construction, the National Electrical Code requires the installation of "Ground Fault Circuit Interrupters" (GFCI's) in any electrical outlet within six feet of a water source. GFCI's measure the current going out to the load and compare it with the current coming back from the load. If there is a difference of even 5 milliamps (5/1000 of an amp), the GFCI grounding receptacle interrupts the current within 0.17 seconds and so prevents serious electrical shock. Ground fault circuit interrupters are available for individual outlets or for circuit breaker boxes for entire circuit protection.

2. Every science classroom should have a master electrical turn-off switch.

3. Shield all live electrical switches and connections. Clearly label all switches and circuit breakers.

4. Make sure hands and all work areas are dry.

5. Teachers should check all circuits before the power is turned on.

6. When assembling circuits, connect the live portion last. When disassembling, disconnect the live portion first.

Electrical Equipment

1. Electrical equipment should be safely grounded.

2. Avoid the use of extension cords if possible, especially in traffic areas. Any electrical cords on the floor should be held down by tape or an extension cord cover (available at most hardware stores). It is helpful to loosely wrap an extension or electrical cord from an appliance around a table leg to help absorb the force of pull in case a person trips over the cord. This tactic may help to prevent equipment from being pulled off the table.

3. All electrical cords should be inspected regularly for wear and damage. Remind students to pull the plug and not the cord when disconnecting a plug from an outlet.

4. Discontinue use of any electrical equipment which is working erratically or producing "tingles." Have the equipment repaired or replaced.

5. Do not place electrical equipment near a water source, if at all possible. If lab tables contain both water and electrical outlets, these outlets should have ground fault interruption devices. Check with an electrician for advice.

6. 110-volt Underwriters Laboratory or equivalent listed equipment is recommended.

Glassware

Most accidents in the school laboratory involve cuts or burns from glass.

Selection

1. Flaws, scratches, chips, and cracks create stress points and lessen the strength of glass. Don't use any chipped or cracked glassware. Reduce scratches by using rubber-tipped stirring rods and coated clamps, and by cleaning glassware immediately after use.

2. Only Pyrex or a similar heat-treated brand should be used for heating. Heat and cool glass slowly (don't set a hot beaker on a cold or damp counter).

Disposal

Have a special container only for disposal of broken glass. Clean up broken glass immediately; have gloves and a brush and pan for that purpose. Wet cotton is useful for cleaning up very small pieces of glass.

Cleaning

1. The sooner done, the easier the job. If the glassware can't be washed immediately, let it soak somewhere out of the way.

2. Don't use worn brushes with exposed metal that may scratch the glass.

3. **Chromate cleaning solutions are dangerous and not recommended for school use.** Many other cleaning agents are available, and most glassware can be cleaned with hot water and detergents.

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4. Be sure to remove all detergent. It will react with acids to form a grease coating on the glassware.

Management

1. Wear gloves or wrap glass tubing in a towel before breaking the tubing. Commercially made glass tube cutters work well. Wear safety goggles when cutting glass. Fire-polish ends of tubing.

2. Lubricate glass tubing or thermometers with glycerin, water, or stopcock grease before insertion into a rubber stopper. Wear gloves or use a towel for hand protection.

3. Remove glass tubing or thermometers from rubber stoppers as soon as possible to prevent the adherence of the rubber or cork to the glass. If the tubing or thermometer does stick to the stopper, only the teacher should attempt to separate the two. It is advisable to cut the rubber stopper when a thermometer is involved to avoid thermometer breakage.

4. Students should not try to release frozen glass stoppers, ground joints, or stopcocks. The teacher should wear gloves and goggles, and may be able to release the frozen area by running a stream of hot water over it. A strip of paper between ground joints, frequent lubrication of stopcocks, or taking apart the equipment for storage will help limit the problem.

Heat Sources

All science laboratories should have central shut-off valves and switches for gas and electricity.

1. Use smooth-surface hot plates as a heat source when possible, especially if any flammable liquid is involved. Clean the plate surface after each use as soon as it has cooled.

2. Alcohol burners can be very dangerous. Check for cracks or chips, and fill prior to student use. Use a plastic squeeze-type bottle to refill with alcohol or a burner fuel, making sure the burner has cooled before adding fuel. Add a pinch of salt to pure alcohol in the burner so the flame may be seen. Be sure a fire extinguisher is nearby. Many duplicating fluids contain heavy metals such as lead compounds, and are not recommended for use in alcohol burners due to byproducts produced from burning. Ask for a material safety data sheet (MSDS) from the supplier of the duplicating fluid to verify purity if this fluid is to be used.

3. Match the burner to the type of gas available, i.e. natural, artificial, or L.P. gas. Many lab suppliers have Meker, Bunsen, and other burners available for each gas type.

4. Gas lighters are readily available, inexpensive, and safer than matches.

Lasers

The high intensity beam of a higher class laser may present many hazards, especially to the eyes. Tell the students not to look into a laser beam or stare at beam reflections. Safety rules are included in the operating instructions for the laser. Read them carefully and store the rules with the laser equipment.

1. The greatest hazard is probably to the eyes; even low-power beams may burn the retina if stared at, resulting in permanent visual damage. Laser goggles are rated for the wavelength and power of a particular laser, and are not automatically interchangeable between lasers. ***Safety goggles worn for chemical safety are not suitable for work with lasers.*** The laser beam should be at waist level or below whenever possible.

2. The Bureau of Radiological Health has classified lasers as Class I to Class IV, with Class II and III-A normally recommended for secondary school use. Class II, referred to as "low-power lasers," do not have enough output power to injure a person accidentally but could be responsible for retinal injury if stared at for long periods. Class III-A may cause injury when energy is collected.

3. For student safety:
   a) require use of laser goggles and disinfect them after student use (see p. 18).
   b) make sure the laser is never pointed at anyone.
   c) never stare at the laser from within the beam.
   d) never view reflected beams.
   e) block off the beam past the target (a sheet of rough wood or a flat piece of carbon available at industrial lighting stores works well). The target or any objects in the beam area should be non-reflective.
   f) never leave the laser unattended. Prevent unauthorized access.
   g) be sure the laser cord is grounded.
   h) set up prisms and mirrors in advance to avoid unexpected reflections.
   I) avoid other accidental reflections by removing rings, watches, necklaces, wall mirrors, etc.

Model Rockets

A detailed model rocketry code should be available from the supplier of the rockets, or the *Code for Unmanned Rockets* (#1122) is available from the National Fire Protection Association, Batterymarch Park, Quincy, MA 0269 (800-344-3555). Check local and/or city regulations before launching, including contact with the nearest air traffic control facility if applicable.

The National Association of Rocketry - Hobby Industry of America has these guidelines for use of model rockets:

1. Model rockets should be made of lightweight materials such as paper, wood, plastic and rubber with no structural parts made of metal.

2. The total weight of the rocket and engine should not exceed 453 grams, and the engine may contain no more than 133 grams of propellant.

3. Only solid-propellant, factory-made model rocket engines should be used. The student should not attempt to alter or reload these engines.

4. Remotely controlled and electrically operated launching systems should be used, and all students need to be at a safe distance from any rocket being launched. That safe distance will depend upon the size of the rocket being launched, but 15 feet may be a guideline.

5. Launch the rockets only in clear areas in calm weather conditions.

6. Never attempt to recover a rocket from power lines or other dangerous places.

Model Steam Engines

Some model steam engines contain spirit burners. Pure alcohol burns with an invisible flame. Most accidents occur when the flame appears to have gone out, the burner is refilled, and the vapor and the stock can of alcohol are ignited.

1. Salt may be added so that the flame is more visible, but a safer alternative is to use steam engines with burners for solid fuel. Be sure to use the type of fuel recommended by the manufacturer, and fill only to the recommended level.

2. Care should be taken to avoid burns from the steam or from contact with hot parts of the engine.

Noise Production

Administrative Guidelines for School Safety, published by the Missouri Department of Elementary and Secondary Education in 1977, lists the following permissible noise exposures:

Duration per day, hours	Sound level dBA
16	80
6	85
4	90
2	95
1	100
½	105
1/4	110
1/8	115

Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level. There should be no exposure to continuous or intermittent noise in excess of 115 dBA.

Radiation Sources

The Sun

1. There is no safe eye protection available for use of the sun as a direct light source, and activities using the sun in this manner are not recommended. If lenses and prisms are used with the sun as a light source, very close supervision is necessary.

2. Viewing an eclipse is difficult with any student, as most find it difficult to never glance at the partially blocked sun. Even with the sun's brightness lessened, there are still sufficient direct ultraviolet rays striking the retina of the eye to cause permanent damage. Smoked glass, exposed film, and welder shields do not provide sufficient protection for the eyes. Indirect viewing using a sun projection screen on a telescope and direct viewing with sun filters on telescopes are acceptable methods for responsible students, if done with close teacher supervision and with reliable equipment.

The National Society to Prevent Blindness recommends the following indirect method for viewing a solar eclipse:

a) Get two sheets of white cardboard.
b) Make a pinhole in the center of one of the sheets.
c) *Stand with your back to the sun.*
d) Hold the sheet with the hole in it so that the sun shines through that hole onto the cardboard held in the other hand.
e) Adjust the sheets of cardboard to obtain the desired image size (change the distance between the sheets).
f) By looking at the bottom sheet, an image of the sun can be seen as the moon slowly crosses in front of it.

3. Solar energy collectors and devices operated by solar energy, such as solar hot dog cookers, can get very hot. Caution the students to exercise care.

Method for viewing a solar eclipse.

Infrared and Ultraviolet

Ultraviolet light can cause an inflammation of the conjunctiva of the eye called conjunctivitis, detachment of the retina, or severe "sunburn." Infrared radiation can damage the eye lens and produce cataracts. Infrared/ ultraviolet goggles or glasses with side shields should be worn if the source is not already shielded. An approved welders' face shield is also effective protection. Mercury light sources are capable of emitting ultraviolet rays, so eye protection is required.

Microwaves

High intensity microwaves are suspected health hazards; unnecessary exposure should be avoided.

Radioactive Materials

"License free" or "exempt quantity" sources are strongly recommended for use in the classroom. Missouri Statute 192.440 requires that any other radioactive materials be registered with the

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Missouri Department of Health. The following information is taken from Appendix I, Table 1, of *Radiation Protection*, a booklet from the Missouri Department of Health:

Exempt quantities of radioisotopes

Radioisotope	Unsealed Sources (Microcuries)	Sealed Sources (Microcuries)
Cesium-Barium 137	10	100
Cobalt-60	10	100
Polonium-210	0.1	1.0
Strontium-Yttrium 90	0.1	1.0
Uranium-233	0.1	1.0
Natural Uranium	1000	10000

As noted, naturally occurring uranium ores are largely unregulated. That does not necessarily make them safe, and radiation exposure from these ores should be evaluated before use.

Sealed radiation sources, though not appropriate for all activities, should be used when possible. To limit exposure, the smallest amount of material should be used for the shortest possible time, and skin contact should be reasonably avoided. The Missouri Department of Health recommends that protective clothing (gloves, aprons, safety glasses) be used when handling radioactive materials, especially liquid sources. As with other chemistry experiments, food and drink should be off-limits during radioisotope labs, and hands should be washed following the experiments. Radioactive solutions should NEVER be pipetted by mouth.

The Health Department also recommends that the lab area, equipment used, students, and teachers be monitored for contamination after working with radioisotopes. Absorbent material should be used when handling liquid sources.

Most schools have very small amounts of radioactive materials that present no real concern. Extra caution should be taken, however, if the teacher or a student is pregnant, especially during the first three months of pregnancy. Though it is generally accepted that doses greater than 10 Rad are required to produce health hazards to the fetus, there is no need to be negligent. The exposure limit for individuals exposed to non-occupational, non-medical radiation is 100 millirad per year or one percent of the threshold level of 10 Rad.

Radioactive sources should not be stored in the classroom but in a separate storage room. Missouri Statute 192.430 states, "All sources of radiation shall be shielded, transported, handled, used and kept so as to prevent all users thereof and all persons within effective range of them from being exposed to unnecessary radiation." An area is considered a "radiation area" if "radiation levels exist which could subject an individual, continuously present, to five (5) millirems within any one hour" (19 CSR 20-10.100). Any such area must be labeled with "Caution: Radiation Area" signs. A middle or secondary school should *not* be storing sufficient radioactive material to fall into this category.

The disposal of any waste materials which still produce radiation must meet state hazardous waste disposal regulations. (See page 43) If there is no detectable radiation, the material may be disposed of as normal trash. Most schools keep their radioactive sources until natural decay has removed most of the radioactivity. After seven half-lives, less than 1% of the activity remains.

For further information, contact the Missouri Department of Health Bureau of Environmental Epidemiology (Non-Medical Radiation Sources) at (573) 751-6160. The Internet has several training manuals from various educational institutions for working with radioactive materials. Do a search for *Radiation and Health Physics* to the *Educational Information* link put together by the University of Michigan.

X-rays

X-ray tubes and any device which uses electron beams, such as cathode ray tubes, microwave tubes, or television tubes, are capable of producing x-rays. The three types of cathode ray tubes commonly used in the classroom (the heat effect tube, the magnetic or deflection effect tube, and the shadow or fluorescence effect tube) may produce x-rays while in use and should be used with extreme care. The output of the tube is strongly dependent upon the voltage and current capabilities of the

power source, so tubes should be operated at the lowest possible current and voltage with operation time at a minimum. The glass in any vacuum tube (including Guinea and Feather Tubes) becomes brittle with age, and the low interior pressure can cause implosions. It is recommended that cathode ray tubes be used *only by the teacher* for demonstrations, and that the students stand at least eight feet from the tube when it is in use.

Thermometers

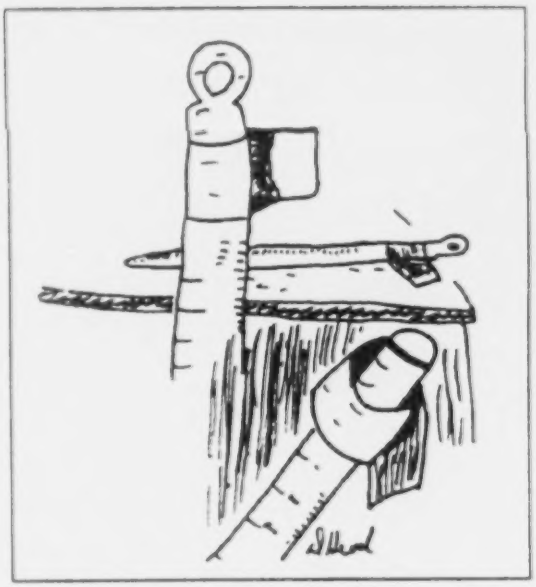
Alcohol or n-hexane thermometers are recommended in place of mercury thermometers unless extreme accuracy is required for an experiment. Mercury quickly vaporizes and is readily absorbed from inhaled air through the pulmonary system. Elemental mercury is a central nervous system poison. It is very difficult to clean up all of a mercury spill (see p. 22 for suggestions). If a mercury thermometer is required, consider using one with a Teflon coating which will help to retain the mercury even if the glass is broken. Metal or non-mercury thermometers are recommended for use in an oven. Breakage of a glass mercury thermometer would send mercury vapor throughout the oven and lab.

The following guidelines will help to prevent thermometer breakage:

1. Purchase anti-roll triangular tip thermometers, or an anti-roll device. A "flag" made with a piece of tape is also helpful.

2. Do not allow thermometers to be used as stirring rods.

3. **Never swing a thermometer to try to reunite separated columns of mercury**. Flinn Scientific, Inc. recommends that thermometer columns be reunited by immersing the bulb (and *only* the bulb, not the thermometer stem or column) in a 150 Pyrex beaker containing about 1 in^3 of dry ice and 75 ml of acetone or isopropyl alcohol. The mercury should fall back into the bulb. You may need to try this more than one time, be sure to let the bulb warm for 3-5 minutes before repeating the procedure. Do not stick fingers into the dry ice solution, do not touch the supercooled bulb until it has warmed for several minutes at room temperature, and do this procedure on a tray in case of thermometer breakage. See the Flinn Reference Manual for more details.



Tape "flags" to help prevent rolling thermometers.

4. Never use an open flame on the thermometer bulb.

CHEMICALS

The management of chemicals represents one of the major challenges facing science teachers today. Almost all the chemicals in a laboratory are toxic or hazardous to some degree, and it is the responsibility of the teacher to be familiar with possible problems. The teacher must do everything within reason to reduce any hazard and ensure that the benefit exceeds the possible risk of any activity. A teacher is also responsible for safe storage of the substances, and must make arrangement for safe disposal of unwanted chemicals and waste products.

Hazardous Chemicals

Under OSHA guidelines stated in Code of Federal Regulations (CFR) 1910.1200, a hazardous chemical is any chemical that is a physical or health hazard to people or the environment. In schools, these chemicals are usually corrosives, flammables, toxics, or oxidizers/ reactives. Remember that a chemical may present more than one hazard.

1. **Corrosives** are defined as any materials that can injure body tissues or are damaging to metal by direct chemical reaction. The more common corrosives found in schools include acids (sulfuric, acetic, hydrochloric, nitric, etc.), bases (sodium hydroxide, aqueous ammonia, etc.), and others such as iodine, bromine, acetic anhydride, and ferric chloride. These chemicals should not contact skin or eyes. Goggles must be worn, and aprons, gloves, and possibly face shields should be considered. Corrosives should always be stored below eye level.

2. **Flammable liquids** are involved in nearly one fourth of all accidents and fires in science laboratories. The liquids themselves usually do not burn, but produce vapors that are flammable. Most organic solvents should be considered fire hazards unless they are definitely known to be nonflammable. In addition to common solvents such as acetone, ethanol, and toluene, glacial acetic acid is also moderately flammable. Flammable solids sublime, and their vapors are as dangerous as vapors from a flammable liquid. All flammables should be stored in an OSHA-approved flammables cabinet and kept away from heat and direct sunlight when out of the cabinet. Most of the vapors produced are more dense than air and can disperse throughout a large room. Many students will be sensitive to the narcotic effects of the fumes of flammable liquids, so these chemicals should be used only in fume hoods or well-ventilated areas. The smallest reasonable amount of flammable chemicals should be used, and never around any source of ignition.

3. **Toxic substances** may enter the body by inhalation, ingestion (by mouth), by absorption through skin, or by injection. Some effects are acute, meaning the effects occur immediately or within a few hours. An example is methyl alcohol, which can cause blindness or death if minimal amounts are ingested or inhaled. Other effects are chronic and result from repeated exposure over months or years. Chronic toxins, such as benzene, formaldehyde, and other carcinogens, are of particular concern for teachers. Toxic effects are dose dependent, so exposure must be limited by using the smallest amount of chemical for the shortest time possible and wearing protective clothing.

4. **Oxidizers and reactives** include chemicals which can explode, violently polymerize, form explosive peroxides, or react violently with water or oxygen. Student use must be carefully evaluated for risk vs. educational benefit. Oxidizers, which include nitric acid, hydrogen peroxide, potassium nitrate and nitrite, and many others, must be stored separately from combustible materials. Some explosives are mentioned on the following page in the Inventory section. Acrylonitrile and butadiene are two chemicals which can form hazardous polymers upon aging. Some aldehydes, ethers, ketones, vinyl compounds, and many other substances can form explosive peroxides in a few months (check the MSDS). Peroxide production can be slowed down by storage in full containers (so buy the smallest container possible), by closing containers as soon as possible, and by tightly closing container lids or caps. These methods will limit oxygen

exposure. Chemicals which violently react with water or oxygen include calcium carbide, sodium, and magnesium powder.

There are many more chemicals in each of these categories, and Material Safety Data Sheets, the Merck Index, or NIOSH Pocket Guide to Chemical Hazards (see below) should be consulted for identification.

General Guidelines

1. **Material Safety Data Sheets (MSDS) are the most complete source of information about physical data, health and fire hazards, reactivity, spill procedures, handling procedures, and first aid for any substance.** Some companies send MSDS only upon request (and they should always be requested), but are required by law to supply MSDS for any hazardous chemical purchased from that company. Several science supply companies sell MSDS books, containing information for hundreds of chemicals. MSDS are also available online through the Internet. A search will bring up several MSDS sources including:

http://www.sargentwelch.com/safetyck.html
http://pegasus.uthct.edu/ResUTHCT/MSDS/JTBaker/JTBaker.html
gopher://atlas.chem.utah.edu/11/MSDS
http://www.enviro-net.com/technical/msds/

"Chemical Hazard Response Information System (CHRIS): Hazardous Chemical Data" (Document number 050-012-00215-1) is a primary source of information from which many sources obtain data for MSDS. This publication contains information for over 1000 substances, and is available for sale by the U.S. Government Printing Office (address on p. 66).

The National Institute for Occupational Safety and Health (NIOSH) provides an easy-to-use source of chemical information. The *NIOSH Pocket Guide to Chemical Hazards*, publication number 94-116, is available in hard copy, CD-ROM, and diskette format (call 1-800-35-NIOSH for purchase information or contact the U.S. Government Printing Office). Some supply catalogs include specific safety information in the chemical sections. No chemical should be used or handled until the label and MSDS have been read and understood.

2. **Use the smallest amount of chemical possible in any experiment.** This limits costs, student exposure, and waste.

3. **Do not leave storage containers of substances in the classroom during an activity.** In case of an accident, larger amounts of chemicals present more of a hazard. The students should not have access to chemicals other than the amount needed for an activity.

4. **Use a sturdy cart or at least a strong bucket to transport bottles of hazardous chemicals.** Glass bottles are easily dropped.

5. **Instruct the students about safe methods for working with chemicals.** Remind them how to safely smell a substance by the "waft" method, to always add acid to water, to add boiling stones prior to boiling to prevent "bumping," etc. Additional guidelines are on page 12.

6. **Do not return unused chemicals to stock bottles.** Contamination may cause unwanted reactions and disposal is expensive.

Inventory and Reorder

A chemical inventory should be conducted at least once a year. For reasons of personal safety, the inventory should be conducted by two persons working together (no students). Safety clothing such as goggles, gloves, and aprons should be worn, and the storeroom should be well ventilated.

1. **Some chemicals may be found during an initial inventory which should be not be moved by other than trained bomb squads or other qualified officials.** *School Science Laboratories - A Guide to Some Hazardous Substances*, prepared by the Council of State Science Supervisors and published by the U.S. Consumer Product Safety Com-

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mission, lists the following substances as explosives:

Benzoyl Peroxide
Carbon Disulfide
Diisopropyl Ether
Ethyl Ether
Perchloric Acid
Picric Acid
Potassium Metal

The Guide states that these explosives should be removed by trained fire or police bomb squads in order to minimize the chance of unplanned detonation. If no other help is available and there is a public safety concern, the Missouri State Highway Patrol Explosives Disposal Unit (see p. 66) will help to remove picric acid and old ethers. Nitrogen triiodide and sodium azide are among other chemicals that are very unstable and explosive. Consult Material Safety Data Sheets, the Merck Index, or another reliable source for hazards of other substances.

2. **Decide how to record inventory information before starting the inventory.** Recorded information may include the chemical name, formula, concentration, approximate age or condition, amount, and storage container type and size. Information may be read into a tape recorder for later transcription, or recorded on a computer print-out sheet or other prepared form.

3. **If at all possible, have a centralized purchasing program per school or district.** This will prevent duplicate ordering and allow the purchase of bulk quantities.

4. **Reorder only the quantities of chemicals which are needed for the next 1-2 years.** Disposal costs of unwanted chemicals exceed any savings from ordering larger amounts. Consider purchase of chemicals from a company that includes hazard, first aid, storage, and purchase date information on the label. If the substance is not dated when received, write the date on the label with a permanent marker to aid in future inventory.

5. **Consider placing a small piece of brightly colored tape on the lid of a chemical container when you use the chemical.** This will make it easy to spot those substances which have not been used in a year or more so they may be considered for disposal.

Storage

Chemicals need to be stored in compatible chemical groups in a centralized locked storage room. Students should not have access to this area. If chemicals must be stored on shelves in the classroom, the shelves should be covered with wooden doors with locks. Chemicals should never be stored in direct sunlight.

The following guidelines are proposed in order to promote safe working conditions and to reduce waste through breakage, spills, and deterioration of chemicals.

1. **Chemicals should not be stored in alphabetical order, but in compatible family groups.** A system placing sodium dithionite (a strong reducing agent) next to sodium dichromate (a strong oxidizer) creates a potential danger. See page 47 for a partial listing of other chemicals which are incompatible. Many computer software programs are available which contain chemical storage patterns. Several chemical supply companies, including J. T. Baker, Flinn Scientific, and Sargent Welch, have storage methods described in their catalogs.

2. **The storage room should contain or be readily accessible to safety equipment including fire extinguishers, eyewash stations, and safety showers.** Automatic fire extinguishers and alarms which are heat and/or smoke activated should be considered.

3. **The chemical storage room should not contain metal shelving, metal shelf supports, or metal cabinets.** Chemical fumes will cause deterioration of the metal. All storage units should be firmly attached to walls. Free standing units are not recommended, especially for chemicals or heavy equipment storage.

4. **All shelves should have anti-roll lips.** This is especially important in any area which may be affected by an earthquake.

5. **Chemicals should not be stored more than two-deep on a shelf, should not be stored above eye level, and should not be stored on the floor.**

6. **Acids (with nitric acid separate), poisons, and flammables should be stored in specific cabinets designed for that family of chemicals.** Materials that are incompatible should never be stored in the same cabinet. OSHA 1910.1450 states, "Chemicals which are highly toxic... should be in unbreakable secondary containers." This would include corrosives, flammables, etc. as well as poisons. A "secondary container" is something that will contain and control a chemical in case of a spill, broken bottle, etc. Poison cabinets should be locked.

7. **Chemicals should be stored at the correct temperature.** Storage recommendations should be clearly displayed on the label.

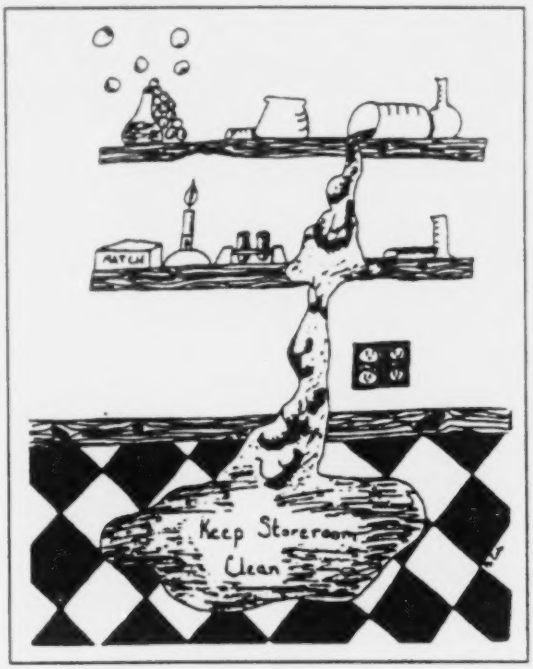
8. **Household-type refrigerators should not be used for chemical storage.** The switches may spark, igniting flammable materials. Refrigerators which are "explosion proof" and meet National Fire Protection Association standards have modified internal wiring, sealed motors and switches, and are acceptable for chemical storage.

9. **Chemicals should not be stored in fume hoods.**

10. **The storage room should be well ventilated and have two exits.** The storage room should not be used for mixing and transferring chemicals.

11. **A method should be organized for relocation of chemicals after use so that integrity of the compatible groupings is maintained.** A computer inventory program can simplify the process of finding a chemical on the shelf if the computer is located near the storeroom. An alphabetized printout, manual listing, or file card system also works well. It is helpful to code each shelf area by group. Mark that code on the label of the chemical with a waterproof marker so that the substance is returned to the correct shelf after use.

12. **Periodically inspect stored chemicals for signs of leakage, deterioration, loose labels, or other problems.**



Waste Minimization

It is obvious that reducing the amount of waste, especially hazardous waste, generated in the science laboratory is important. The teacher is demonstrating environmental responsibility, making it easier to comply with waste disposal requirements, and saving money from disposal costs.

1. **Reduce waste production at the source.** This is the most desirable method to manage waste. disposal problems are limited because the wastes are not produced.

One method of reducing waste at the source is by reducing experimental scale. Most macroscale experiments can be scaled down by up to 50% with little effort or change in equipment. See the following section for information on microscale chemistry.

where 1/100th to 1/1000th of the original quantities of materials are used.

Another method of hazardous waste source reduction is to substitute non- or less-hazardous chemicals within experiments. For example, use alcohol or hexane thermometers in place of mercury thermometers if an extreme degree of accuracy is unnecessary, use cyclohexane in place of benzene in molecular weight determination/freezing point experiments, store biological specimens in isopropyl alcohol, sodium citrate, or other safer preservative in place of formaldehyde, or use cyclohexane in place of carbon tetrachloride in halide ion tests. A 40% glyoxal solution may be substituted for formalin (a 40% formaldehyde solution) in some demonstrations. Students should not be working with these hazardous chemicals, and it is expensive to dispose of them as regulated waste. When you discontinue use of the hazardous chemical, any amount remaining in the inventory will require legal disposal as a hazardous waste. Be sure no more is ordered.

An easy method of waste reduction is to buy only the amount of chemical needed within the next one-two years (at most). Most chemistry labs contain chemicals which were purchased in bulk several years ago and have either gone bad or are no longer needed. The American Chemical Society estimates that unused chemicals can make up to 40% of the wastes generated by a lab. Disposal costs more than any original savings. If you don't buy it, you don't have to get rid of it.

Make sure all chemicals are clearly labeled. If a label is coming off a container, fix it. Clearly and at least semi-permanently label all solutions or mixtures you make (no water-soluble marking pens and be very careful with wax pencil identifications). Disposal of unknown substances increases the disposal cost by up to six times.

Be sure that chemicals are safely stored so that breakage, spills, and deterioration are limited. See the prior section on Storage.

2. **Recover or recycle laboratory wastes and give away unneeded chemicals.** Recovery methods should only be attempted if the teacher is comfortable with the chemistry methods required. As a "small quantity generator" schools are not required to get a permit or certification to recycle wastes onsite. However, you must notify the DNR Hazardous Program of resource recovery, solvent purification, or waste treatment (as in #3 below) activities (address on p. 66; this ruling is from Title 10 of the Code of State Regulations 25-9.020).

Recovery of chemicals can be a learning tool for students, and may be presented as the final step in a chemistry experiment or as a project for more advanced chemistry students. Some lab manuals present "closed loop" experiments where the by-products of one experiment become the reagents/reactants for the next experiment.

If you use larger quantities of organic solvents, it may be worth your time to use distillation processes for purification. Commercially available "stills" or existing lab equipment may be used to fairly easily distill xylene, methanol, acetone, or other solvents. Peroxide-forming solvents should not be distilled. Use standard safety procedures when performing this process, and contact the local fire department to ensure compliance with any local regulations.

Some metals, especially silver, can be fairly easily reclaimed. A few companies will clean contaminated mercury, as from thermometers or barometers. They will provide Department-of-Transportation-approved containers for accumulation and transport. See page 65 under 'mercury' for resources.

Give away excess usable chemicals to other schools, colleges, researchers, or industry. Contact the local American Chemical Society for suggestions. If the chemicals are in good condition, someone may have a use for them. This method works best if direct communication is made with someone known to the person making the contact. As a small quantity generator, school personnel may transport chemicals within Missouri as long as regulated quantities are not exceeded (see the Disposal section, below) and chemicals will be <u>used</u> by the recipient in a production or experimental process. <u>Waste</u> chemicals may not be transported without a permit. There are two exchange programs in Missouri which may be helpful for getting rid of larger amounts of unopened chemicals. Contact the

Environmental Improvement and Energy Resources Authority at (573) 751-4919 regarding the Industrial Material Exchange Service or the Missouri Department of Economic Development at 1-800-523-1434, ext. 5 and ask for Missouri Product Finder information.

3. **Some hazardous wastes may be treated so they are non- or less hazardous.** For example, acids or bases may be carefully neutralized and then flushed down the drain with a 20-fold excess of water. The Flinn Chemical Catalog/Reference Manual (address on p. 65) contains over 40 pages of chemical treatment for disposal methods. Be sure to read their cautions at the beginning of the section; many of these treatments should only be done by experienced chemists and may not be allowed by Missouri or local regulations. Missouri law allows a generator to treat ignitable, corrosive, or reactive wastes (no "listed" wastes - see Disposal section below) on site.

Some of this information was adapted from *Laboratory Waste Minimization and Pollution Prevention: A Guide for Teachers*, which is distributed by the Missouri Department of Natural Resources (DNR). Contact the Technical Assistance Program of the DNR, 1-800-361-4827, to obtain a copy of the 59-page booklet.

Microscale Chemistry

Microscale chemistry is a method of reducing the amount of chemicals used in an experiment. The amount of reduction may be from 1/100th to 1/1000th of the original experiment. The result is less waste, less student exposure, and fewer chemical purchases. Reaction time is often reduced. Microscale chemistry was originally associated with organic chemistry procedures, but there are now many microscale lab manuals for general/inorganic chemistry. This method presents the following advantages:

1. **It is economical.** Significantly smaller amount of chemicals are needed. Microscale reductions require microscale glassware, which is normally less expensive than full-scale glassware. There is an initial investment needed for this equipment, but costs are typically recovered in less than three years.

2. **It is safer.** The students and teachers are exposed to fewer health and injury hazards from the chemicals and reactions because of the reduced chemical amounts used. Spills are easier to manage. Laboratory air quality is improved.

3. **Less waste is produced.** This is an advantage for the environment and also helps to limit the cost of chemical waste disposal.

4. **Less storage space is required.** Microscale glassware needs less shelf space, and smaller amounts of chemicals are needed.

Contact the science supply companies and science text publishers for more information about equipment and lab manuals for microscale chemistry.

Disposal

Lab wastes, old or unsafe chemicals, substances no longer used, and "mystery" chemicals that have lost their labels require some method of disposal. Federal, state, and local laws regulate the amount and kinds of chemicals which may be put in a landfill or into the sewage system. A waste management program should be developed in each district which helps the teacher recognize hazardous waste and understand proper disposal. There are several options for substance disposal, but each school or school district must make its own arrangements according to local restrictions of landfills, sewer systems, or other treatment works.

Missouri schools are considered "conditionally exempt small quantity generators" (CESQG's). CESQG's do not generate 100 kg (220 lbs) or more of nonacute ("U" list) hazardous waste in one month or accumulate that amount at any time, never generate more than one kg (2.2 lbs) of acute ("P" list) wastes in one month, etc. The complete set of rules is found in Title 10 of the Code of State Regulations (10 CSR 25-4.261(2)(A)10. The complete lists of

"U" and "P" chemicals may also be found in Title 40 of the Code of Federal Regulations, Chapter 1, part 261.31, which may be accessed on the Internet under Code of Federal Regulations. A few of the "U" and "P" chemicals which might still be found in some school laboratories are listed:

"U" List Chemicals

- Acetaldehyde
- Acetone
- Benzene
- Chloroform
- Ethyl ether
- Formaldehyde
- Hydrogen sulfide
- Several lead compounds
- Mercury
- Methanol
- Napthalene
- Phenol
- Toluene

"P" List Chemicals:

- Several arsenic compounds
- Several cyanide compounds
- Carbon disulfide
- Fluorine
- Several nickel compounds

As CESQG's, schools are exempt from many regulations, but certain requirements do apply.

1. **A hazardous or unknown chemical may not be put down the drain or in the trash.** Do not discharge any waste into the sanitary sewer system without first obtaining the permission of local wastewater officials. Solvents are not suitable for discharge into the sewer. As of January 1, 1994, Section 260.432 of the Missouri Hazardous Waste Management Law prohibits placement of any but the very smallest (*de minimus* - for example, the amount left in a container even after it has been rinsed) amounts of hazardous waste into Missouri sanitary landfills. Environmental responsibility prohibits the teacher from knowingly allowing any hazardous waste to be placed in a landfill or sewer system.

2. **Schools, as CESQG's, may treat or dispose of hazardous waste in an onsite facility.** Possible methods are previously discussed in the Waste Minimization section, part 3. Schools may not burn the waste or dispose of it into the environment. Waste may not be dumped on the ground, used wastes (such as solvents) may not be used to kill weeds, and waste may not be buried in the ground at an unpermitted site.

DNR Disposal Option

The Missouri Department of Natural Resources (DNR) has developed a program to help schools dispose of unwanted chemicals. Public school districts are considered state agencies so the schools can utilize a statewide service contract entitled "Hazardous Waste Disposal Contract." Each school is required to pay all costs for the disposal of their waste chemicals. The school sends an inventory of unwanted chemicals to several of the DNR-approved disposal companies, and a free cost estimate for on-site packing, removal, transport, and disposal of the chemicals is returned. The school works directly with the disposal company. Preserved biological specimens and radiation wastes are also accepted. Most hazardous substances from the art, industrial arts, and custodial departments may be included in this disposal program. Smaller schools may save money by pooling inventory lists with other schools or districts when asking for estimates.

Schools may also use this program for disposal of laboratory wastes on a semi-annual or annual basis, after the initial storage room cleanup. This plan will help schools save money because of the competitive bidding, and will reduce the amount of paperwork required by a school for appropriate chemical disposal. Contact the Missouri Office of Administration at (573) 751-4887 for more information.

Temporary Storage of Chemical Waste

Temporary storage of laboratory wastes and old or unneeded chemicals may be required prior to disposal. Be sure that incompatible materials are segregated during storage. For example, ignitables should be stored away from oxidizers or solvents. Acids should be away from bases. Do not mix organic and inorganic wastes. Halogenated and non-halogenated solvents should not be mixed. Mixing a listed hazardous waste with a non-hazardous waste will usually result in the entire volume being regulated as a hazardous waste. Dilution for

the purpose of rendering waste non-hazardous is strictly forbidden. The disposal service you select will be able to provide more specific instructions for accumulation and storage.

Laboratory waste should be segregated based on chemical compatibilities, and should be placed in tightly closed compatible containers. For example, do not stored acid waste in metal containers.

Unneeded, deteriorated, or 'mystery' chemicals should be removed from the classroom area. Remember that schools, as small quantity generators, may not store more than 2200 pounds (1000 kg) of waste and may never store any waste more than 270 days (usually only 180 days) according to the Missouri Hazardous Waste Management Law. Divide the waste substances into chemically compatible groups, using the same divisions as for storage or as prescribed by the disposal service. Leave each chemical in its original container (or a compatible lab-safe bag, if the container is damaged), and place each group of chemicals in a separate sturdy box. Surround each bottle within the box with an absorbent, non-flammable material such as kitty litter, vermiculite, or dry white sand. Each box should be clearly labeled, including names of all substances in the box, approximate quantities, and the date each substance was declared a waste. Have the custodial department carefully store the boxes in some isolated area which does not reach freezing temperatures and is away from heat and water sources. *Store the waste containers so that they may be regularly inspected (don't pile containers on top of each other) for damage or leaks.* School administrators, science teachers, custodians, and local fire department officials should be aware of the location of these stored chemicals.

Right to Know/Hazard Communication

A school having any Extremely Hazardous Substances in amounts above the threshold planning quantity (TPQ) on its premises must notify the Local Emergency Planning Committee (LEPC) and the State Emergency Response Commission (SERC) at 1-800-780-1014. In this situation, the school facility is subject to planning provisions and should be included in the local response plan. However, the TPQ should be far above any amount found in a school laboratory, and so science teachers should not have to worry about this regulation. Examples of chemicals which may be found in the school lab and their TPQ include ammonia (500 pounds), several arsenic compounds (100-500 pounds), formaldehyde (500 pounds), and sulfuric acid (1000 pounds). This is obviously not a problem for the science department. If a school has a swimming pool and stores over 100 pounds of chlorine at any time, the school administration will need to follow the planning requirements.

Community Right to Know refers to available Material Safety Data Sheets and the submission of inventory and chemical location information to the LEPC, the SERC, and the local fire department. Public schools do not have to comply with these regulations unless they store above the TPQ of certain chemicals (as mentioned above), except that they must supply the information if requested. Even though not required, it would be helpful for all schools to give the local fire department an inventory and storage location of chemicals in case of a fire emergency.

For more information, contact the Missouri Department of Natural Resources, U.S. Environmental Protection Agency, or the U.S. EPA RCRA/Superfund Hotline at 1-800-424-9346.

The OSHA Laboratory Standard

As units of government or "public entities," public schools in Missouri are not yet required to follow OSHA regulations. Private schools must comply with all federal standards (including OSHA) as well as any applicable state laws. In Missouri, the Division of Labor Standards has the right to enforce OSHA regulations, but does not for schools unless there has been a serious accident reported. A school which does not comply with generally accepted guidelines (such as the OSHA Lab Standard 29 CFR 1910.1200) could then be found negligent.

It is therefore recommended that all schools make some effort to comply with OSHA regulations. Most of the guidelines make good sense for accident preparedness and are recommended in other

sections of this manual. Putting safety instructions in writing is a real help in providing guidance for the inexperienced or undertrained teacher. The basic component of the Laboratory Standard is the development of a Chemical Hygiene Plan (CHP) which describes procedures and training for working with hazardous chemicals.

It is the responsibility of the "chief executive officer" of the school to appoint a "chemical hygiene officer." The chemical hygiene officer should be qualified by training or experience to oversee the CHP process. Time and appropriate compensation should be provided for this extra work. Larger school districts may have a district as well as a local school chemical hygiene officer.

A **Chemical Hygiene Plan** should include the following sections:

1. **Introduction.** This may include the CHP goals and a list of personnel responsible for development and implementation of the plan, as well as emergency phone numbers.

2. **General principles.** This is a listing of guidelines for working with laboratory chemicals.

3. **Standard Operating Procedures.** This may include a first aid policy (when to see the school nurse, a doctor, or treat in class), general laboratory rules (similar to those on p. 5), protective clothing requirements (see pp. 5, 23), spill and accident procedures (see pp. 17-24), personal behaviors (regarding hair, clothing, housekeeping, horseplay, etc., possibly similar to a safety contract, p. 13), chemical storage guidelines (see p. 40), safety equipment use and maintenance, etc. Pages could be copied or adapted from this manual and inserted where appropriate.

4. **Record-keeping Requirements.** This would include procedures for reporting accidents, routine laboratory and safety inspections, maintenance of equipment, reviewing the CHP, etc.

5. **Safety Training Opportunities.** Safety training must be provided for any employee of the school who may be exposed to hazardous chemicals. In addition to the teacher, this includes teachers' aides, administrators who may participate in safety inventories, and maintenance or janitorial personnel. OHSA regulations apply to employees, so students or classroom visitors are not officially covered by a CHP. However, it is good practice to include information on safety instruction and procedures for students or other persons. At a minimum, the training for employees could include information about safe practices for working with hazardous chemicals, an explanation of labels and MSDS's, and emergency and first aid procedures.

6. **Emergency Response Procedures.** What is the appropriate response to fire, a chemical spill, an injured or ill student, hazardous equipment, etc? Plans should be made for contacting the school office or nurse, the fire department, or other emergency personnel. What are the procedures for room or school evacuation? These plans should be in writing, posted, and practiced.

In addition to the CHP, the standard requires that hazardous chemicals (purchased or made in the lab) be clearly labeled with the chemical name, hazard information, and manufacturer information (if purchased). MSDS received with chemical orders and other appropriate reference materials should be maintained for all hazardous chemicals, and readily accessible to employees.

Most, if not all, universities in Missouri have CHP's or something similar by another name. Contact their "hazardous materials coordinator" or chemical hygiene officer for help. Flinn Scientific Inc. (see p. 65) offers a free "Generic Chemicals Hygiene Plan for High School Laboratories" which lists general employee rules and procedures, laboratory rules, protective clothing requirements, and other information, as well as space for individual school guidelines. The American Chemical Society (see p. 65) also offers "A Model Chemical Hygiene Plan for High Schools" for $15.95 plus S&H. This document is a CHP, and little would need to be done unless the school wants to personalize it. Documentation would need to be provided to show that the CHP had been implemented into school procedures.

Examples of Incompatible Chemicals

This listing is not intended to be all-inclusive, but only gives examples of some of the chemicals which should not be allowed to contact each other in uncontrolled situations. Consult the Material Safety Data Sheets for more information about any substance in question.

Chemical	Is Incompatible With
Acetic Acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates, ammonium nitrate
Acetic anhydride	Water
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Acetone	Concentrated nitric and sulfuric acid mixtures
Alkali and alkaline earth metals (powdered Al or Mg, Ca, Li, Na, K)	Water, chlorinated hydrocarbons, carbon dioxide, halogens
Aluminum metal	Ammonium nitrate, antimony trichloride, any bromate, chlorate, or iodate, bromine vapor
Ammonia (anhydrous)	Mercury, chlorine, calcium hypochlorite, iodine, bromine
Ammonium nitrate	Acids, powdered metals, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Calcium oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials, acids, reducing agents
Copper	Acetylene, hydrogen peroxide
Cyanides	Acids
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Hydrocarbons (such as butane, propane	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrogen peroxide (6% or more)	Copper, chromium, iron and iron oxides, most metals and their salts, alcohols, acetone, organic materials, aniline, combustible materials
Hydrogen sulfide	Fuming nitric acid, oxidizing gases

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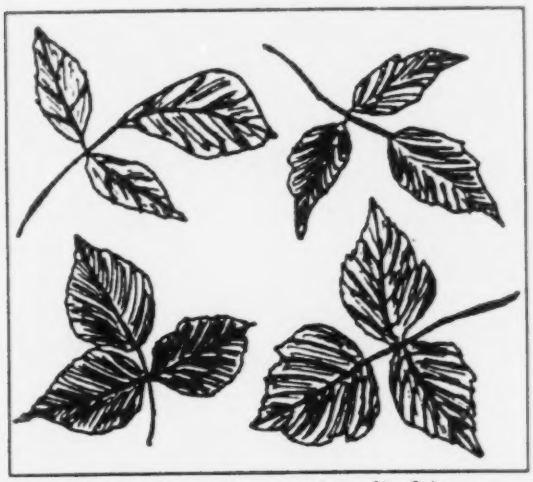
Iodine	Acetylene, ammonia, hydrogen
Mercury	Acetylene, ammonia
Nitrates	Sulfuric acid, reducing agents
Nitric acid (concentrated)	Acetic acid, alcohol, aniline, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals, phosphorous
Nitrites	Acids
Oxalic acid	Silver, mercury
Oxygen	Oils, grease, hydrogen; flammable liquids, solids, or gases
Potassium	Water, carbon dioxide
Potassium permanganate	Glycerol, ethylene glycol, sulfuric acid
Selenides	Reducing agents, acids
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds
Sodium	Water, carbon dioxide, sulfur
Sodium nitrate	Ammonium nitrate and other ammonium salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate
Sulfides	Acids
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate and other similar compounds of light metals such as sodium or lithium, most metals, reducing agents, carbohydrates
Toluene	Strong oxidizing agents, strong acids

PLANTS and FUNGI

Most people in Missouri are familiar with poison ivy, which students may contact on school grounds or during field trips. Other plants present hazards which may not be as well known; there are hundreds of relatively common plants in Missouri which may cause symptoms ranging from skin irritation to vomiting to death in susceptible people. The potential for plant poisoning varies depending on amount and pathway of exposure as well as personal sensitivity. Teachers should be familiar with the possible hazards presented by any plant used in a learning experience. See the following pages for a list of toxin-containing plants.



Poison ivy or oak may have a variety of leaf shapes, though there are always 3 leaves. It may grow as a trailing or climbing vine or shrub.

A free pamphlet "Poison Ivy" is available from the Conservation Department and details information on differentiating between poison ivy and other plants. A USDA booklet, *Poison Ivy, Poison Oak and Poison Sumac,* is available from the local Missouri Extension Office. For more information about poisonous plants, contact:

Tim Smith, State Botanist
Missouri Conservation Department
P.O. Box 180
Jefferson City, MO 65102-0180

The Missouri Department of Conservation sells the book *Wild Edibles of Missouri* for under $5.00. This book also includes information about non-edibles and has several pages of color plant pictures to aid in identification. There are many other sources of information concerning plant poisoning including *Human Poisoning From Native and Cultivated Plants* by Hardin and Arena (Duke University Press), *Medical Botany: Plants Affecting Man's Health* by Lewis and Elvin-Lewis (John Wiley & Sons), *and Poisonous Plants of the Central United States* by H. A. Stephens (Lawrence: The Regents Press of Kansas).

Guidelines for Working With Plants

1. Wash hands with soap and water after handling any plant. This is especially important before handling or eating food.

2. Do not spread plant sap, juice, or oils into the eyes or an open wound.

3. Never eat any unknown seeds, berries, fruit, or other plant part.

4. Never pick any unknown plant or plant part.

5. Remember to treat insecticides, fertilizers, and other plant chemicals as hazardous substances.

Mushrooms

Although mushrooms are not plants, the prevention of exposure to toxins from mushrooms is similar to that of plants. Mushrooms are the fruiting bodies of a fungus. There are edible mushrooms that are easy to recognize and hard to confuse with anything dangerously poisonous. The booklet *Edible and Poisonous Mushrooms* from the Missouri Department of Conservation contains several pages of color drawings and information about the mushrooms commonly found in Missouri.

Missouri Plant Information

This represents only a partial listing of toxin-containing plants in Missouri. Symptoms will vary *depending on amount of exposure and student sensitivity.* <u>The possible risk is through ingestion, unless otherwise noted.</u>

PLANT	POISONOUS PART	SYMPTOMS
Apple	Seeds	Breathing difficulty, spasms, coma, death
Buckeye	Leaves, flowers, sprouts, nuts	Vomiting, diarrhea, weakness, dilated pupils, depression, paralysis
Caladium	All parts	Intense burning of mucous membranes, may cause swelling of tongue and throat to block air passage
Castor bean	Seed	Severe vomiting, diarrhea, convulsions, kidney damage, death; highly poisonous
Daffodil	Bulb	Vomiting, diarrhea
Dieffenbachia	All parts	Intense burning and mouth irritation, swelling may block air passages, known as "dumb cane"
English ivy	Berries and leaves	Stomach pains, diarrhea, difficult breathing
Four o'clock	Roots and seeds	Vomiting, diarrhea, abdominal pain
Foxglove	Leaves	Vomiting, diarrhea, headache, irregular heartbeat, genus *Digitalis*
Holly	Berries	Vomiting, diarrhea, central nervous system depression
Hydrangea	Leaves and buds	Vomiting, diarrhea, gasping, rapid breathing
Iris	Rhizome, flower stalks, leaves	Vomiting, diarrhea, blisters of lips and mouth
Jack-in-the-pulpit	Rhizomes	Dermatitis
Japanese yew	All parts especially the seeds	Vomiting, diarrhea, dilated pupils, convulsions
Jimson weed	All parts	Thirst, dilated pupils, flushing, hallucinations, headache, nausea
Jonquil or narcissus	Bulb	Vomiting and diarrhea

Lily of the Valley	Leaves and flowers	Vomiting, irregular heartbeat
Mayapple or mandrake	Green fruits, roots and foliage	Vomiting and diarrhea
Milkweed	Leaves, stems and sap (*can be irritating to skin)*	Stomach and intestinal upset, possible skin irritation
Mistletoe	Berries	Acute stomach and intestinal irritation, diarrhea, slow pulse
Nightshade	All parts	Vomiting, diarrhea, convulsions, respiratory and nervous system depression
Osage Orange	Milky juice *(by contact)*	Dermatitis, blistering possible
Philodendron, split leaf	Leaves	Burning of mouth, vomiting, diarrhea
Poinsettia	Leaves, stems, flowers	Not highly toxic as once thought; recent studies indicate that it may cause some gastric irritation and burning of the mouth (Source: U.S. Consumer Product Safety Commission and Poison Prevention Council, 1996)
Poison Ivy or Oak	Sap from all parts (*by skin contact, by ingestion, and airborne for very sensitive persons)*	Blisters, itching, ingestion may cause serious irritation and swelling
Pokeweed	All parts	Vomiting, diarrhea, abdominal pain, respiratory depression, convulsions, death
Potato or tomato	Leaves	Cardiac depression
Privet	Leaves and berries	Vomiting, diarrhea, low blood pressure, kidney damage
Rhododendron	All parts	Nausea, vomiting, dizziness, breathing difficulty
Rhubarb	Leaves	Burning of mouth and throat, vomiting, diarrhea
Stinging nettle	Stinging hairs (*by contact)*	Dermatitis, itching
Sweet pea	Seeds	Slow or weak pulse, shallow breathing, paralysis, convulsions
Trumpet creeper	Leaves, flowers *(by contact)*	Dermatitis
Virginia creeper	Berries	Vomiting, diarrhea (deaths reported)
Wild parsnip	All parts *(by contact)*	Dermatitis

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Animal Care and Handling

The use of animals in the classroom can help to instill and sustain an interest in animals and nature. Science teachers can help students develop a positive attitude toward animals by focusing on the uniqueness of each animal and its relationship to the environment.

The science teacher has the primary responsibility for the care of live animals in the classroom, and for the conditions under which any school-related study that involves live animals is conducted. Most animals require specific diets and special living conditions. The animals need full-time care, so arrangements must be made for weekends and holidays. Failure to meet the needs of the animals will result in a deterioration of the animals' physical and mental health, and may ultimately cause death. See page 55 for a care chart for common laboratory animals.

All animals used in the classroom must be legally acquired according to state and local laws. All mammals used in the classroom should be vaccinated against rabies, unless purchased from a reliable biological supply company. Any pet brought to class should have a clean bill of health from a veterinarian.

The National Association of Biology Teachers (NABT) endorses "Principles and Guidelines for the Use of Animals in Precollege Education." Copies may be obtained from NABT or the Institute of Laboratory Animals Resources (see p. 65 for addresses). The NABT Position Statement on "The Use of Animals in Biology Education" is similar to that of NSTA and is available at their web site (NABTer@AOL.COM).

The National Science Teachers Association Position Statement

The following statement, reprinted with permission, may serve as a guideline for use of animals in schools.

Guidelines for Responsible Use of Animals in the Classroom

These guidelines are recommended by the National Science Teachers Association for use by science educators and students. They apply, in particular, to the use of nonhuman animals in instructional activities planned and/or supervised by teachers who teach science at the precollege level.

Observation and experimentation with living organisms give students unique perspectives of life processes that are not provided by other modes of instruction. Studying animals in the classroom enables students to develop skills of observation and comparison, a sense of stewardship, and an appreciation for the unity, interrelationships, and complexity of life. This study, however, requires appropriate, humane care of the organism. Teachers are expected to be knowledgeable about the proper care of organisms under study and the safety of their students. These are the guidelines recommended by NSTA concerning the responsible use of animals in a school classroom laboratory.

- *Acquisition and care of animals must be appropriate to the species.*
- *Student classwork and science projects involving animals must be under the supervision of a science teacher or other trained professional.*
- *Teachers sponsoring or supervising the use of animals in instructional activities--including acquisition, care, and disposition--will adhere to local, state, and national laws, policies, and regulations regarding the organisms.*
- *Teachers must instruct students on safety precautions for handling live animals or animal specimens.*
- *Plans for the future care or disposition of animals at the conclusion of the study must be developed and implemented.*
- *Laboratory and dissection activities must be conducted with consideration and appreciation for the organism.*

- *Laboratory and dissection activities must be conducted in a clean and organized work space with care and laboratory precision.*
- *Laboratory and dissection activities must be based on carefully planned objectives.*
- *Laboratory and dissection objectives must be appropriate to the maturity level of the student.*
- *Student views or beliefs sensitive to dissection must be considered; the teacher will respond appropriately.*

- Adopted by the NSTA Board of Directors, July, 1991

Projects Involving Animals

The National Science Education Leadership Association has established guidelines for the use of animals in schools and school projects.

1. Protista and other invertebrates are preferable for most experiments involving animals due to the wide variety of invertebrates and the feasibility of using larger numbers.

2. A qualified adult supervisor who has had training in the proper care and handling of laboratory animals *must* assume primary responsibility for the conditions of any experiment that involves living vertebrates. No experiment should be undertaken that involves drugs, organisms pathogenic to man or other vertebrates, ionizing radiation, carcinogens, or surgical procedures, unless these procedures have been approved by and will be performed under the immediate supervision of a biomedical scientist experienced and qualified in the field under investigation. A biomedical scientist must have one of the following degrees: Ph.D, M.D., D.V.M., or D.D.S. and must be actively engaged in the field under investigation. A general practitioner (physician, veterinarian, or dentist) would not be considered to be qualified for supervision of projects involving surgery, instrumentation, or experimental pharmacology.

Science for Life: Exploring Animal Models in Basic Research is an instructional resource developed by the Department of Biological Science at Florida State University (1992). This set of materials, which won the SEPA award from the National Institutes of Health, includes a video tape that outlines basic research procedures, a history of the use of animals in research, parameters for animal care, and position papers from several sources. For more information, contact:

Kevin Vidergar
237 Conradi Building
Department of Biological Science
Florida State University
Tallahassee, FL 32306-2043

The Use of Animals in Competitive Events

Competitive events (Science Fairs, Missouri Jr. Academy of Science, International Science and Engineering Fair, etc.) all have published guidelines and requirements governing the use of animals in research projects. Contact the event directors for specific details concerning how to obtain animals, the choice of animals, animal care, euthanasia, and dispensing and disposal of animals.

Use of Hypodermic Syringes

Hypodermic syringes are used in the biology laboratory for several projects, such as testing the effects of testosterone on chicks, injecting earthworm nephridia with methylene blue, and inducing ovulation in frogs by pituitary injection.

1. **Use of hypodermic syringes by students must be very closely monitored by the teacher.** Students should be well informed of the potential harmful effects such as puncture wounds, hepatitis, and embolism. Students should learn to avoid recapping needles at all and simply dispose of the sharp instrument immediately.

2. **Used syringes/needles should be immediately placed in a Sharps Container.** This container should be a clearly labeled puncture-resistant box. Biohazard containers are available from medical suppliers and some science supply companies.

3. **Keep all containers for new and used hypodermic syringes in locked storage.**

Physiological Data for Common Laboratory Animals*

This information is offered as a guideline for care of animals in the classroom.

Animal (female)	Rabbit	Rat	Mouse	Guinea Pig	Hamster
Breeding life (yrs)	1-3	1	1	3	1
Gestation period (days)	31	21	20	68	16
Duration of estrous cycle (days)	15-16	4-5	4-5	16-19	4
Duration of estrous (days)	30	1 (6 hrs)	1 (3 hrs)	1 (6-15 hrs)	1 (4-23 hrs)
Litter size	1-13	6-9	1-12	1-8	1-12
Weaning age (wks)	8	3-4	3	2-3	3-4
Breeding age (mos)	6-7	2-3	2	3	2
Birth weight (gm)	100	5-6	1.5	75-100	2
Weaning weight (gm)	1000-1500	40-50	10-12	250	35
Eyes open (days)	10	10-12	11	Birth	15
Body temp (°C)	39.4	38.2	37.4	38.6	38.0
Resp. rate (breaths/min)	53	85	160	90	83
Heart rate (beats/min)	200	328	600	300	450
Blood pressure (mm Hg)	110/80	130/90	120/75	77/50	108/77
Adult daily water intake (ml)	300	35	6	145	30
Adult daily food intake (gm)	180	10	5	12	10
Adult metabolism (cal/Kg/day)	110	130	600	100	250
Environmental temp. range (°F)	60-72	65-75	68-78	65-75	65-75
Relative hum. (%)	45-50	45-50	45-50	45-50	45-50
Floor space/animal (sq ft)	2-5	0.4	0.4	0.7	0.34
Adult body wt. (kg)	3.7	0.45	0.035	0.43	0.12
Life span, ave. (yrs)	6	3	1.5	3	1

* Information compiled by Cynthia Besch-Williford, D.V.M., Ph.D., Associate Director, Research Animal Diagnostic and Investigative Laboratory, University of Missouri - Columbia

Dissection of Animals

The National Association of Biology Teachers (NABT Position Paper, 1995) confirms the importance of the study of organisms to the understanding of life on earth. They support experiences with nonhuman animals as long as the activities are conducted within established guidelines of proper care and use of animals.

The National Science Teachers' Association promotes the following guidelines:

- *Laboratory and dissection activities must be conducted with consideration and appreciation for the organism.*
- *Laboratory and dissection activities must be conducted in a clean and organized work space with care and laboratory precision.*
- *Laboratory and dissection activities must be based on carefully planned objectives.*
- *Laboratory and dissection activities must be appropriate to the maturity level of the students.*
- *Student views or beliefs sensitive to dissection must be considered; the teacher will respond appropriately.*

Safety Considerations

1. **Avoid dissection of dead animals found on highways or in fields.** Discourage students who want to bring the dead animals to class for "show and tell." The animal may have been diseased.

2. **Rubber gloves should be worn when removing specimens from the preservative solution, and forceps or tongs should be used.**

3. **Purchase specimens which are shipped in low toxicity preservatives.** Formaldehyde and formalin (a solution of formaldehyde, water, and methanol) are no longer commonly used as preservatives. Ethylene glycol is a significant ingredient of most non-formaldehyde preservative fluids. Ethylene glycol is toxic by ingestion, and even small amounts can be lethal (LD50 4700mg/kg), so normal safety precautions should be taken. Many biological supply houses have developed a holding and shipping fluid which is registered under a trademark name. Ask for an MSDS for this trademark product. The shipping and holding fluids may still irritate sensitive skin or present other hazards, so thorough rinsing of the specimen and the wearing of gloves is recommended. Good room ventilation is required.

4. **Any specimen held in a formalin solution should be soaked in a water bath in a fume hood and then thoroughly rinsed under running water for several minutes before use. Gloves should be required.** Some schools may have older specimens which are still stored in formaldehyde or formalin. Formaldehyde and formalin are listed as carcinogens by the EPA and are a strong irritant. Good room ventilation is required when working with these specimens. If at all possible, these specimens or at least the holding solutions should be replaced by safer alternatives.

5. **Goggles are recommended for wear during dissection procedures.** It is possible for pieces of tissue or fluids to spatter into the eye of the student or teacher.

6. **Scalpels and dissecting instruments should be sterilized before and after experiments.** Scissors are safer to use, whenever possible.

7. **Leave scalpel blades in the original package when pushing the scalpel onto the blade.** Hold the blade in the package securely, keeping the cutting edge away from fingers. Use tweezers, forceps, or a hemostat to remove the blade, always pushing the blade away from the body.

8. **Avoid holding the specimen in the hand during dissection.** A waxed pan or similar device should be used for holding the specimen in place.

9. **Cut down on the specimen and not up toward the body of the student or teacher.**

10. **Keep dissecting instruments in locked storage.** Place old blades in a Sharps Container (a clearly marked puncture-resistant box).

11. **Hands should be thoroughly washed after dissection activities.**

Alternatives to Dissection

According to an article in the November, 1988 issue of *The Science Teacher*, the frequency and intensity of student protests against the use of animals in biology classes is increasing. The National Association of Biology Teachers' (NABT) Position Statement on "The Use of Animals in Biology Education" (1995) states "The Association encourages teachers to be sensitive to substantive student objection to dissection and to consider providing appropriate lessons for those students when necessary."

The cost of preserved specimens is also limiting the numbers of dissections done in the secondary classroom. The NABT Statement goes on to say that although no alternative can substitute for the actual experience of dissection, models and multimedia may be used if the learning objectives do not require dissection. Biological supply companies offer models, films, videos, computer simulations, CD ROMs, plastinated specimens, and other materials which may be used for teaching anatomy and physiology. The National Association for the Advancement of Humane Education (NAHEE) provides a list of sources for biometers, computer software programs, anatomical models, and video programs. The address for NAHEE is on page 66.

Insect Anesthetizing and Killing Materials

Possible Anesthetics:

1. **Ether** has a long history of effective use as an anesthetic, but is flammable and may form explosive peroxides. Some supply companies sell small amounts of ether which contains a peroxide inhibitor. It should never be stored more than 3-6 months; pay attention to the expiration date. Ether should be used under a hood or in a well-ventilated area

2. **Triethylamine** is a common substitute for ether and is sold under several trade names. It is flammable, moderately toxic by ingestion, corrosive to skin and eyes, but is still safer than ether. It should be used in well-ventilated areas. This substance does not work as quickly or as well as ether.

3. Most insects can be anesthetized without damage by freezing them in a jar or "cryolizer" for up to an hour.

Insect killing materials:

1. **Ethyl acetate** is recommended for use in insect killing jars. Though it is a fire hazard and explosion risk, a skin and eye irritant, and is mildly toxic, ethyl acetate is still considered safer than the alternatives listed below, #2.

2. **Cyanide, carbon tetrachloride, and ether** have also been used to kill insects, but are not recommended. Cyanide salts, such as sodium cyanide, are severely toxic. Carbon tetrachloride is a carcinogen and is poisonous. Ether was discussed above, and should not be used when an effective and safety alternative is available.

3. An effective non-chemical method of killing insects is to place them in an airtight container in the freezer for a day or two.

Wild Animals

Wild animals do not make good pets, and are not recommended for use in the classroom on a general basis as they often require specialized care. Without such care they may become ill and eventually die. Wild animals can transmit diseases to humans and may exhibit unpredictable behaviors. See page 29 for information about animal bites and stings. The Missouri Department of Conservation offers the following information:

1. **Baby animals are rarely abandoned.** Many times the parent animal is afraid to show itself when people are near, or may simply be out hunting food. If the baby is left alone, the parent will usually return. Even baby birds which have fallen from a nest will continue to receive parent care if the baby is carefully returned to the nest. As wild animals

mature, they can become dangerous to handle and damaging to property.

2. **A wild animal that has been declawed, defanged or descented will not be accepted by a zoo and will die if released into the wild.**

3. **Mites, ticks, lice, fleas, flukes, roundworms, tapeworms, rabies, distemper, tuberculosis, respiratory diseases and skin diseases caused by a fungus are carried by native wildlife.** Some of these diseases can be transmitted to humans.

4. **Bird nests are full of disease-carrying organisms and are illegal to take.** Students should be discouraged from touching nests in the spring and summer when the parasite problem is greatest. Nests found in the late fall or winter after the birds are gone will be somewhat safer but still infested. The safest method to handle nests is to put them in a see-through seal-lock bag. Make sure hands are thoroughly washed after handling nests.

5. **Wild bird eggs are protected by state law and should not be taken.** However, the eggs are often brought into the classsroom despite teacher instruction. The shells of eggs are generally safe to handle after thorough disinfecting, but unhatched eggs will rot and can explode after a few days from the interior build-up of gases. This will produce very unpleasant odors.

6. **Wild animals are protected by law.** It is illegal to possess many wild animals without a valid state or federal permit. The *Wildlife Code of Missouri*, Chapters 4 and 9, contains detailed information, but it may be easier to contact the local conservation agent with specific questions as to what is legal and safe. Conservation department representatives can also provide suggestions for care and release of the animal back to the wild after it has been studied.

A Wildlife Collector's Permit is required for any teacher or student who collects or possesses wildlife for scientific research purposes. The permits may be issued to professionally qualified individuals for specified projects. Valid permits are also required for bird banding and for rehabilitation of any sick or injured wildlife.

Wildlife in the Classroom

In spite of the state regulations, students will bring animals, nests and eggs into the classroom. What should the teacher do?

Teachers should be aware that the collection of animals, including their young, eggs and nests, is regulated by federal and state law. Special scientific collection permits may be necessary for those species which fall under the jurisdiction of the *Wildlife Code of Missouri*. According to Chapter 9 of the Code (1997), Missouri citizens may confine or keep up to five non-migratory native wildlife specimens provided they are not game species, considered dangerous to humans, or endangered (also see Code, Chapter 4).

The Missouri Department of Conservation offers help to teachers through the local conservation agent and through education consultants. The Missouri Department of Con-servation (address on p. 65) has an excellent collection of materials and films for use in schools. Parks and Recreation personnel, where available, may also be good sources of information.

Venomous Animals and Insects in Missouri

1. **There are five species of venomous snakes generally found in Missouri.** The majority of snakes (at least 88%) are harmless. The venomous snakes include the Osage Copperhead, the Western Cottonmouth (water moccasin), the Eastern Massasauga Rattlesnake (swamp rattler), Western Pygmy Rattlesnake (ground rattler), and the Timber Rattlesnake. The *Snakes of Missouri* booklet from the conservation department has color pictures of these as well as of the common harmless snakes.

Most snakes will try to avoid humans if given a chance. Educate students to back away from a snake when it is encountered or allow the snake to move a good distance away before advancing farther on a trail. The pamphlet *Snakes and People* by T.

Johnson from the Missouri Department of Conservation contains information about snake and human interaction. *Amphibians and Reptiles of Missouri*, also from the Department of Conservation, sells for about $11.00. Further information is also available from the St. Louis Herpetological Society (see p. 66 for addresses).

2. **Wasps, bees, hornets, and mud daubers are often found on school grounds.** The free publication *Common Missouri Wasps and Bees* from the Department of Conservation has pictures and information about the common wasps, mud daubers, velvet ants, bees, hornets, etc. Know which students have allergies to stings and get medical help as soon as possible if the student is stung. The May 1991 issue of *The* American Biology Teacher contains an article, *Bee Stings & Their Consequences* by Rupp, which details reaction types, immunological mechanisms, venom components, etc.

3. **Black widow and brown recluse spiders are found throughout Missouri.** The black widow spider is shiny black with distinctive red hour-glass shaped spots on the underside of the abdomen. Its bite creates severe discomfort but usually not death. The brown recluse is usually a grayish-yellow-brown, with a violin-shaped marking on top of the carapace. While death from a bite is unlikely, a deep open wound can appear after several days which may be slow to heal and prone to infection. Bites most frequently occur when a hand is placed into a dark or shady space where these spiders prefer to live. See page 29 for first aid treatment for spider bites. The free booklet *Common Missouri Spiders* from the Department of Conservation has good pictures and information.

4. **Ticks can carry disease, and bites can become infected.** Encourage protective clothing (hats, long sleeves, long pants with pant legs tucked into shoes, no sandals) and use of repellents with DET on field trips. Inspect for ticks after field work. Ticks in Missouri can carry (in order of incidence) Tularemia, Rocky Mountain Spotted Fever, Erlichiosis, and Borreliosis. These ticks are about the size of a sesame seed, and so are hard to see. Although there is a lot of attention given to Lyme disease, the CDC and Missouri Health Department state that 94% of all Lyme Disease is found in Northeastern United States and does not present a problem in Missouri. All these diseases can be treated with antibiotics. The Missouri Department of Health offers the free pamphlets *Questions and Answers About Lyme Disease* and *Tick Facts*. The Lyme Disease Foundation may be contacted at 1-800-886-LYME.

ADDITIONAL SAFETY CONSIDERATIONS FOR BIOLOGICAL LABORATORIES

The National Association of Biology Teachers (NABT) offers Position Statements on a variety of subjects pertaining to the teaching of biology. The statements are available by emailing to NABTer@aol.com and asking for a particular statement, at http://www.nabt.org/ on the Internet, or by calling (703) 471-1134.

MICROORGANISMS

Standard Microbiological Practices from the Centers for Disease Control and National Institutes of Health
(used with permission, paraphrased)

1. Access to the laboratory is limited at the discretion of the laboratory director when experiments are in progress.

2. Work surfaces are decontaminated once per class and after any spill of materials. A 1:10 household bleach and water solution may be used for disinfection.

3. All contaminated liquid or solid wastes are decontaminated before disposal. These materials may be steam sterilized (autoclaved) or soaked in a 10% bleach solution for at least one hour.

4. Mechanical pipetting devices are used; mouth pipetting is prohibited.

5. Eating, drinking, smoking, and applying cosmetics is prohibited in the work area. Food should not be stored in the science refrigerators.

6. Everyone washes their hands after handling materials and before leaving the laboratory.

7. All procedures are performed carefully (avoid shaking the inoculating loop, don't agitate liquids, use least amount of material possible in loop) to minimize splashing and popping and the production of aerosols. Work in a draft-free area.

8. Laboratory coats or aprons are recommended to prevent contamination of regular clothing. (Though not mentioned in this portion of the CDC-NIH guidelines, eye goggles should be used to protect from accidental splash of materials.)

9. Work areas should not have any cracks or areas inaccessible to cleaning.

Bacterial Experiments

1. **Be selective in choosing microorganisms**. Do not use pathogenic organisms. Suspected and known human, animal, or plant pathogens will be clearly designated in reputable catalogs.

2. **Disinfect work surfaces at least once a day** (or after each class), and after any spill of active cultures.

3. **NEVER, EVER pipette by mouth**. Pipetting bulbs or pumps should be used in every circumstance.

4. **Wash hands with antibacterial soap** when entering and prior to leaving the laboratory, and any time viable cultures are handled.

5. **Wear eye protection, aprons, and gloves**.

6. **Culture plates inoculated with samples of bacteria gathered by the students, including soil sample bacteria, should remain sealed and should be sterilized before disposal**. Gram stains should be done on known non-pathogenic cultures from a reputable supply company and not on unknown samples randomly collected in a school.

7. **Petri dishes passed around for student inspection of cultures should be bound with tape** to avoid exposure to unknown bacteria.

8. **Immediately replace contaminated cotton plugs in broth cultures.**

9. **Wire loops used for transfer of bacteria cultures should be flamed or placed in an electronic sterilizer after each transfer is made.**

10. **Use standard safety precautions when working with samples of pond water.**

11. **If a culture is dropped and the tube or plate breaks, cover the spill with 70% ethanol for a few minutes.** Then carefully sweep up the contaminated wastes and put them with other contaminated wastes to be autoclaved or incinerated. Do not pick up pieces or glass or touch the culture with hands. The spill area should be cleaned with a decontaminating solution.

12. **Be aware of student allergies and limit contact to allergens.** Many students are allergic to mold, so activities involving mold should be conducted in sealed containers as much as possible. Initial symptoms of allergic reactions include watery eyes, itching, sneezing, and difficult breathing.

13. **Decontaminate all biologically contaminated materials before washing, reuse, or disposal.**

Decontamination of Materials

Laboratory equipment should be decontaminated with chemicals or by use of an autoclave or pressure cooker.

1. **Materials may be soaked in a strong disinfectant such as carbolic acid, cresol, or Lysol for 24 hours before being washed.** All are strong irritants, and contact with liquids or fumes should be limited. A 40% formaldehyde solution is also effective, but not recommended as formaldehyde is listed by the EPA as a carcinogen. If formaldehyde is used, all skin contact should be avoided and work should be performed in the fume hood so no vapors are inhaled.

2. **The teacher should carefully read instructions before using an autoclave or pressure cooker.** If using a pressure cooker, make sure the safety valve is in good working order. Materials may be sterilized by using 15 pounds of pressure at 121°C for 20 minutes. Use approved eye protection and allow the pressure to return to zero before removing the cover or door. Open the stop cock on a pressure cooker and wait until the hissing stops before releasing any clamps. Lift the lid so it is tilted away from the teacher to protect from heat and steam.

3. **Plastic disposable petri dishes may be disinfected and then sterilized (and melted) in an autoclave bag in a pressure cooker or autoclave if an emission-controlled incinerator is not available.** The autoclave bag may then be disposed of in a regular incinerator or landfill.

ELECTROPHORESIS AND BIOTECH LABS

The National Association of Biology Teachers has published a book entitled *Working with DNA and Bacteria in Precollege Science Classrooms* by Toby M. Horn (1993) (see p. 66). The book is also available as an ERIC document (ED370802).

1. **Be sure to purchase electrophoresis equipment which has a safety interlock system through the lid.** If the student removes the lid during the process of electrophoresis, there is a possibility of high voltage shock from the electrodes or through the buffer solution. Some teachers build electrophoresis systems from kits to reduce costs. Make sure the connection to the power supply is complete only when the lid is closed.

2. **Ask for Material Safety Data Sheets (MSDS) when ordering stains.** The MSDS may not be automatically sent with the order, and some stains require special handling or storage because of possible hazards. For example, ethidium bromide is used to stain DNA, but is a potential mutagen under chronic overexposure. The dust is very toxic by inhalation (United States Biochemical Corporation MSDS information), so appropriate protective clothing and adequate ventilation are required. When bound to DNA, ethidium bromide will fluo-

resce brightly under ultraviolet light. Ultraviolet goggles should be worn if the gel is viewed under UV light.

3. **All work surfaces should be water-, heat-, and chemical-resistant.**

4. **Each laboratory should be equipped with standard safety equipment.** This includes an eyewash, safety shower, fire blanket, ABC fire extinguisher, first aid kit, sharps container, biohazard disposal bags, and a sink designated for handwashing with antibacterial soap and disposable towels.

BODY FLUIDS AND TISSUES

The NABT supports the use of body samples only if teachers can ensure safe conditions that prevent the spread of disease (NABT Position Statement, 1996). See pages 59 and 60 for guidelines. Human body samples used in the biology laboratory include blood, cheek cells, feces, mucus, saliva, semen, and urine. All of these samples have the potential to spread communicable disease, and should be treated as biological hazards. NABT recommends that teachers use substitute activities or materials if they cannot guarantee the safe handling, storage, cleanup, and disposal of these human body samples.

Detailed guidelines for handling human body samples are available in 29 Code of Federal Regulations (CFR) part 1910.1450. The *Universal Precautions* approach is recommended in the CFR, where all human body samples are treated as if known to be infectious for HIV, HBV, or other bloodborne pathogens. The CFR is available from government book stores, major libraries, the Internet, or the U.S. Government Printing Office (address on p. 66).

NABT recommends that teachers wishing to use human body samples consider the following minimum precautions (reprinted with permission):

- ***Handling.*** *Students should not be allowed to collect samples without supervision or advice of the teacher. Samples should be collected, handled, and transferred using proper safety apparel: plastic or latex gloves, safety glasses or goggles, and a lab coat or an apron. Students should always wash their hands after any laboratory activity using any type of human body sample.*
- ***Storage.*** *All samples must be used and temporarily stored in labeled, leakproof containers during classroom use. Labeling should include the type of sample, the source of the sample, and the current date. Samples kept for long-term storage must be kept refrigerated in clearly labeled, leakproof containers. Again, labeling should include sample type, sample source, and collection date. Samples must never be stored near food or in refrigerators and freezers being used for food storage. Refrigerators used to store human body samples must be labeled with signs that indicate the presence of biohazard materials of human body samples.*
- ***Cleanup and Disposal.*** *In most areas, human body samples may be disposed of in public sewers as long as the samples are free of parasites and highly contagious pathogens. Check with city or other local agencies before doing so. Samples having parasites and highly contagious pathogens must be sterilized, as described below, before disposal. Laboratory materials contaminated with human body samples must be sterilized before reuse or disposal. Reusable materials, like glassware and microscope slides, can be sterilized using an autoclave (pressurized steam heat at 121°C for 20 minutes) or by soaking in a 10% solution (10 ml of bleach added to 90 ml of tap water) of household strength bleach (household bleach is 5% hypochlorite) for 30 minutes. Bleaching should be followed by a warm soap water wash.*

  Contaminated lancets, needles, or broken glass must be sterilized using an autoclave or bleach treatment before disposal. They must then be discarded in a red "Sharps Container" marked biohazard materials. Sharps Containers are available from biologi-

cal and medical supply companies. Lancets and needles must never be reused. Spills must be decontaminated immediately using bleach that has soaked the area for at least 10 minutes. Contaminated broken glass must be handled with cut-proof gloves or a hand broom. All work surfaces should be wiped down with the 10% bleach solution after completion of the activity.

- *NABT Position Statement on The Use of Human Body Fluids and Tissue Products in Biology Teaching, 1996*

Blood-Typing

If blood-typing is considered to be a necessary part of the curriculum, all the NABT recommendations should be followed. ***In addition*** to the NABT guidelines mentioned in the previous position statement, consider using plastic disposable typing cards instead of slides. Lance holders that propel the lance using a push-button device should be used to allow students to type their own blood so that contamination opportunities between students is minimized..

A variety of alternatives to using student blood samples for typing have been developed. Supply catalogs offer artificial blood or disease-free samples for testing as well as computer programs and videos that demonstrate blood typing. The article *Reducing the Risk of Blood Typing: Substituting Saliva for Safety* by Corner and Corner in The Science Teacher (March, 1994) describes an inexpensive alternative. However, only 80% of the population secretes the target proteins in their saliva.

EARTH SCIENCE SAFETY

Earth Science is a comparatively safe course to teach, but there are a few safety considerations in addition to those applicable from other sections in this manual. The following list is a starting point, but by no means all-inclusive.

1. **Ammonium dichromate volcanoes produce chromium(III) oxide, a carcinogen.** If the teacher believes this is a necessary classroom experience, the volcano should be a teacher demonstration done in a fume hood or outside with the students standing upwind. The teacher should wear protective clothing. The experimental wastes are considered hazardous and require regulated disposal (see the chemical disposal section, p. 43).

2. **Mercury is a neurotoxin.** An open evaporating dish of mercury, as used in some barometers, can produce mercury vapor many times greater than the permissible exposure level. As a hazardous waste, the disposal of any mercury waste must meet state and federal regulations.

3. **Tasting minerals for identification, except for halite, should be discouraged.** Some obvious examples of unsafe-to-taste semimetals include arsenic, antimony, and allemontite; all are poisonous. Use safe tasting methods so that communicable diseases are not spread. One method would be to have the student run the halite sample under water, wet a finger under the running water, touch the finger to the halite, and then touch the finger to the tongue.

4. **Samples of asbestos, a carcinogen, should be kept in clear, unbreakable, sealed containers.** Students should not be able to open the containers. This will provide protection from asbestos dust or fibers.

5. **Use normal precautions when working with radioactive materials such as uranium ores.** Minimize risks by using the smallest sample for the shortest amount of time possible, and by using tongs, forceps, etc. to avoid direct contact. Use sealed samples when possible. Be aware that dinosaur bone material may be radioactive and should be tested before classroom use. It may be helpful to rinse dust off ore samples or hot fossils before student use, and to require hand washing after handling the materials. See page 34 for more information on working with radioactive materials.

6. **Some rocks and minerals can have exceptionally sharp edges, such as chert and obsidian.**

7. **Safety goggles should be worn when chipping, hammering, or sawing rocks or minerals.**

8. **100% UV protection eyewear should be worn when using ultraviolet light to observe phosphorescence and fluorescence in minerals.**

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FIELD TRIPS

Local school regulations should be consulted before any field trip is arranged. The teacher should visit the field activity site prior to the student visit so that specific learning objectives and safety needs may be identified.

General Guidelines

1. **Use authorized trip waiver forms to inform parents or guardians and secure permission for school trips.** This form should be signed and filed with the school for each student participating in the field experience. A school policy should be developed for students failing to return the form. This form should include information about the date, location, time, method of transport, attending adults, purpose of the field trip, and required student clothing. There should be a space for the parent to list special medical needs of the student such as allergies to bee stings, poison ivy, or pollen.

2. **Wear appropriate clothing.** If the trip is into an area where there could be a problem of weed poisoning or tick infestation, hats, long sleeves, long pants tucked into socks or shoes, and proper shoes (no sandals) should be required. Students should be inspected for ticks following the field experience. Colorful clothes and perfumes may attract bees.

3. **Use only school-sanctioned vehicles for transport, driven by school-sanctioned personnel.** Students should not be allowed to drive because of school liability. At least two vehicles should be taken on the field trip in case one is needed for emergency medical transport.

4. **Evaluate student/adult ratio for each field activity.** NSTA recommends adult/ student ratios of no more than 1:10. More adults may be needed for supervision of middle school/junior high age students when visiting an open-space site, such as a zoo, park, or nature trail. It may be helpful to have specific students "assigned" to an adult and have the students stay near that adult throughout the trip.

5. **Take a first aid kit on the trip** for minor scratches and abrasions. Be familiar with first aid treatment for bites, stings, and allergic reactions. Students known to be hypersensitive to bee stings should carry an insect sting emergency kit which the teacher knows how to use. A small cold chemical pack is also useful.

6. **Take a cellular phone along for emergency or informational contact.** The phone also helps to maintain contact between vehicles going to and from the field trip site.

7. **Establish rules for conduct before taking the trip.** Use a buddy system. Do not allow students to carry radios or tape players during the educational portion of the field trip. Decide whether snacks will be allowed. Have an adult at the back of the group to be the "clean-up" person.

8. **Avoid glass collection containers,** which may break and cause cuts and/or loss of specimens.

The Missouri Department of Conservation offers many free pamphlets to aid in identification of plants, animals, soil types, etc. in Missouri. Request the order forms for "Publications" and "Educational Materials." See page 65 for the address and telephone number.

Sources of Information

AIDS Prevention Hotline
Missouri 1-800-533-2437
National 1-800-342-2437

Ace Glass Inc.
(Microscale equipment)
1430 NW Blvd.
P.O. Box 688
Vineland, NJ 08360
(609) 692-3333

American Association for the Advancement of Science
Project on Science, Technology, and Disability
1333 H Street, NW
Washington, DC 20005

American Chemical Society
(To order information including CHP)
P.O. Box 57136
Washington, D.C. 20037-0136
(202) 776-8100

ACS Health and Safety Referral Service
1155 Sixteenth St., N.W.
Washington, D.C. 20036
(202) 872-4515 or 4438

Cardinal Glennon Children's Hospital
(**Missouri Poison System** information center)
1465 South Grand Blvd.
St. Louis, MO 63104
(314) 772-5200
1-800-366-8888

Environmental Improvement and Energy Resources Authority
Industrial Material Exchange Service
(573) 751-4919

EPA - Region 7. See U.S. EPA below

Fisher Scientific EMD
(Chemical, safety, and equipment information)
485 S. Frontage Road
Burr Ridge, IL 60521
1-800-955-1177
http://fisheredu.com/

Flinn Scientific Inc.
(Chemical and Biological Catalog/Reference Manual for safety and equipment information)
P.O. Box 219
Batavia, IL 60510-0219
1-800-452-1261
FlinnSci@aol.com
http://www.flinnsci.com

Institute of Laboratory Animals Resources
2101 Constitution Avenue, NW
Washington, DC 20418
(202) 334-2590

Lab Safety Supply
(Safety supplies and information)
P.O. Box 1368
Janesville, WI 53547-1368
1-800-356-2501

Laboratory Safety Workshop
192 Worchester Road
Natick, MA 01760-2252
(508) 647-1900
Labsafe@aol.com

Mercury Reclaimers
Bethlehem Apparatus Co., Inc., Hellertown, PA (610) 838-7034
Mercury Refining Co., New York, NY (800) 833-3505
Quicksilver Recycling, Brisbane, CA (415) 468-2000
Remlinger, D. J., Seattle, WA (206) 296-4899

Missouri Department of Conservation
P.O. Box 180
Jefferson City, MO 65102-0180
(573) 751-4115

Missouri Department of Economic Development
Missouri Product Finder program
1-800-523-1434, ext. 5

Missouri Department of Elementary and Secondary Education
P.O. Box 480
Jefferson City, MO 65102
(573) 751-4212

MO DESE, continued
C J. Varnon
Science Curriculum Consultant
(573) 751-4445

Missouri Department of Health
1738 East Elm
Jefferson City, MO 65102
(573) 751-6400

Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, MO 65102
1-800-334-6946

Hazardous Waste Program
(573) 751-3176

Waste Management Program
(573) 751-3176
1-800-361-4827

Missouri Emergency Response Commission
Department of Natural Resources
P.O. Box 3133
Jefferson City, MO 65102
(573) 634-2436

Missouri State Highway Patrol
Explosives Disposal Unit
P.O. Box 568
Jefferson City, MO 65102
(573) 526-6122

National Association for the Advancement of Humane Education (NAHEE)
P.O. Box 362
East Haddam, CT 06423
(203) 434-8666

National Association of Biology Teachers
11250 Roger Bacon Drive, #19
Reston, VA 20190
1-800-406-0775
http://www.nabt.org/
NABTer@aol.com

National Fire Protection Association
Batterymarch Park
Quincy, MA 02169
1-800-344-3555

National Institute for Occupational Safety and Health (NIOSH)
NIOSH Publications
Mail Stop C-13
4676 Columbia Parkway
Cincinnati, Ohio 45226-1998
Fax (513) 533-8573
1-800-35-NIOSH

National Science Education Leadership Assoc
P.O. Box 5556
Arlington, VA 22205

National Science Teachers Association
1840 Wilson Blvd.
Arlington, VA 22201-3000
(703) 243-7100

Sargent-Welch
(Microscale equipment, supplies, safety information)
P.O. Box 5229
Buffalo Grove, IL 60089-5229
1-800-727-4368
sarwel@sargentwelch.com
http://www.sargentwelch.com/safetyck.html

SAVI/SELPH, Center for Multisensory Learning
Lawrence Hall of Science
University of California
Berkeley, CA 94720
(510) 642-8941

St. Louis Herpetological Society
P.O. Box 9216
St. Louis, MO 63117

U.S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, KS 66101
(913) 551-7000 or 7051

EPA's Superfund/RCRA Hotline
1-800-424-9346

U.S. Government Printing Office
Superintendent of Documents
United States Government Printing Office
Washington, DC 20402-9325
(202) 512-1800

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Columbia, MO 65201
1-800-366-8232
(573) 882-4694